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EDUCATIONAL PROBLEMS OF THE COLONIAL TERRITORIES

JUST on twenty years ago, in September 1937, the Commission on Higher Education in East Africa, which was under the chairmanship of Earl De La Warr, issued its report. The Commission took as axiomatic that the primary need of East Africa was the improvement of health and agriculture, and that such improvement could best be achieved through the general education of Africans and by training in sufficient numbers qualified African experts. Its first recommendation, that education in East Africa should be based upon the need of the community and should be closely related to environment, was amply endorsed two years ago by the Binns report; and the recommendations relating to education in the recent report of the East Africa Royal Commission of 1953–55 (see *Nature*, July 16, p. 87) are similarly based. It is not too much to say that education lies at the root of almost all the latter Commission's recommendations: they cannot be implemented effectively unless an educational policy on such broad lines is formulated and executed imaginatively and with vision as well as more urgently and on a larger scale than has yet been done.

This is not to disparage the progress that has already been made or to belittle the very considerable achievements of the past two decades. It is rather to emphasize that it is only through education that the African can adapt himself to use the new opportunities which are opening to him in industry and on the land; and also gain a clearer understanding of the changes in traditional African society which are necessary to enable Africans to enjoy the higher standards of living they desire. Without a vigorous and wisely concerted educational policy, the conditions encouraging the exercise of activities favourable to progress cannot be secured, or the co-operation and understanding between the races essential for harmonious development established.

This point is very firmly emphasized by the Commission, which insists that the co-operation of the African is essential for the effective development of East Africa and that this co-operation cannot be secured without dispelling the fears and suspicions which hinder it at present. To that end education is as effective a weapon as it is in promoting the skill and knowledge the African needs for using the new opportunities which confront him. Nor is it any less important in assisting adaptation to the changes in traditional tribal economy which a modern and more productive system demands.

Much that the Commission has to say on education is essentially a re-statement of the findings of the Binns Committee. That Committee saw in a full, comprehensive and balanced education a major solvent of the economic and social problems of East Africa, and it emphasized that the more liberal education it sought for Africans must be based on their own African environment and on their own way of life; and particularly it stressed the paramount importance of agriculture and an attack on agricultural ignorance. Again, it urged that technological education should be developed to keep pace with industrial expansion, in order to enable Africans to make their maximum contribution as skilled workers in accordance with the opportunities of each area. The Binns Committee emphasized, too, the necessity for a close connexion between technical education and industry, and pointed out that successful technical education can only be based on a good general education.

The East African Commission naturally did not pursue the requirements of educational policy in any detail; but it recognizes clearly enough that education is a fundamental service, on the adequacy and efficiency of which all other services depend. For example, new industrial development in Africa requires a large contribution from Africans, even if at present they cannot provide all the managerial ability and capital required; and it is important to enable Africans to acquire the special skill required in modern industry and to create conditions which will allow Africans to exercise the greatest degree of enterprise of which they are at present capable. The difficulties are not primarily financial: they are chiefly deficiencies in knowledge and experience, and a public policy concerned to promote direct African participation in new industrial development should concentrate on removing those deficiencies.

Though education is a basic factor, it is not the only one. Much industrial training will have to be provided by industry itself, although the emergence of a foreman class among the African workers themselves clearly will depend on raising the standards of education as well as on the quality of industrial training. Moreover, the low productivity of ordinary African labour is not due merely to the lack of technical skill but also to various factors, some of which—such as under-nourishment, poor physique, endemic disease and lack of interest in ordinary economic incentives—could be modified or removed by appropriate public policy.

Specifically, the Commission advocates carrying elementary education to a stage at which it will be of permanent benefit to all growing children able to profit by it. Free universal education is, however, a long-term objective. For the present, the Commission suggests providing education for all pupils, at fees which will not exclude any, to the beginning of the intermediate stage, and in towns to the end of the intermediate stage. Secondary education should be obtainable by those prepared to pay for it, and supported by a wide and liberal system of bursaries for those unable to pay but showing clear promise and ability. The proposals of the Binns Committee for eliminating waste and ensuring that pupils complete their courses are supported, and it is suggested that priority should be given to the expansion of intermediate education, preferably as an adjunct to existing primary schools, even if this means temporarily retarding direct progress with primary

education. It is emphasized that a higher standard of training in technical education can scarcely be established except on the basis of eight years primary education.

It is a little surprising, accordingly, in view of this long-established opinion as to the fundamental importance of education in Africa, to find so few references to education in the schemes made under the Colonial Development and Welfare Acts in the returns for 1954–55*. Apart from £37,116 for the expansion of education services in Zanzibar and a further £37,000 for the construction of primary schools and teachers' houses and £7,000 for the adaptation of Kampala Technical School, the only major schemes for education financed in this way are in West Africa, where £228,700 is provided for the construction of students' hostels, lecture theatre, assembly hall and gymnasium for the Nigerian College of Arts, Science and Technology. Under other schemes, £99,314 is provided for the construction of senior staff housing for the Nigerian College of Arts, Science and Technology, and £42,613 for additional accommodation for students and staff at University College, Ibadan. Out of the further £3,763,351 contributed to the development plan for Nigeria, however, £527,828 is earmarked for general education and £455,478 for technical education.

Education, moreover, receives due emphasis in the recent report on the Colonial Territories, 1954–55†, which, noting the continued expansion of educational facilities and the making of new provision for technical and higher technical education in several territories, points out that at the end of 1954 the number of students at the three universities and four university colleges in these territories exceeded four thousand. Enrolment at the Kumasi College of Technology increased to 580, of whom 62 were taking professional courses in engineering; and good progress was made towards the completion of the new buildings in Nairobi of the Royal Technical College of East Africa, for which a further grant of £107,000 was approved from Colonial Development and Welfare Funds.

It is in the context of these findings of the East Africa Commission and the general survey presented in "The Colonial Territories" that the significance of the achievements recorded by the Inter-University Council for Higher Education Overseas in its recent survey of the period 1946–54, and of the findings of the report by PEP entitled "Colonial Students in Britain"‡, are best appreciated. Indeed, "The Colonial Territories, 1954–55" contains a wealth of material which could be used for combating the complete indifference of the general British public to their own great Colonial inheritance, which was noted by PEP, and it should be for consideration whether the presentation of that annual report could be varied so as to deal more effectively with an ignorance which is both generally dismaying to Colonial students and hinders sound judgment and wise decisions on issues affecting all those territories for which Britain is still politically responsible.

To combat such ignorance is the more important when we consider the extent to which these questions are interlocked. It is not simply a matter of providing more information or other effective action to promote understanding between British and Colonial peoples. The growth of the Colonial student population from about 1,000 in 1946 to more than 10,000 in 1955 reflects the need of the Colonial territories for trained men and women in order to accelerate or even maintain development; and that need must in large part be met from overseas until the new university institutions in those territories come to maturity. Although only some thirty-five per cent of such students are at universities, the remainder attending polytechnics, training colleges, or studying under the auspices of such bodies as the Inns of Court, they occupy places in British university institutions to the extent of some two per cent at a time when we are seriously concerned with the ability of those institutions to provide a sufficiency of scientific and technical man-power for the direct needs of Britain.

Colonial education is, moreover, directly linked with this question of scientific and technical man-power, as both the report of the Inter-University Council and the latest report from the Advisory Council on Scientific Policy (Cmd. 9537. London: H.M.S.O. 6*d*. net) indicate. The young universities overseas have close ties with universities in Britain and receive from them invaluable assistance, which makes none the less heavy demands on staff. Such special co-operation will be needed as fully in the immediate future as in the past. Much the same can be said of research. The Advisory Council estimates that only some 450 scientists are at present engaged in Colonial research, and of these less than one hundred are members of the Colonial Research Service. This number is quite inadequate for the important problems awaiting attention, and until the Colonial universities and research institutions have developed considerably, any expansion in research must draw largely on the limited supplies of scientific and technical man-power in Britain itself.

The postgraduate scholarships recommended by the Inter-University Council in another connexion may offer some contribution here; but it is evident that in the present man-power situation the needs of the Colonial territories require the most careful consideration. This factor, as well as their financial needs, should receive due weight in determining priorities and the allocation of our resources, not least when regard is had to the implications of such new developments as that of nuclear power for Britain's own economy. The potentialities of the export trade stressed by Sir Francis Simon recently depend to some extent on the existence of trained men and women in the under-developed areas and on the level of general and technical education there.

* Colonial Development and Welfare Acts: Return of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the period from 1st April, 1954, to 31st March, 1955. Pp. 32. (London: H.M. Stationery Office, 1955.) 1*s*. 3*d*. net.

† Colonial Office. The Colonial Territories, 1954–55. (Cmd. 9489.) Pp. ix+186. (London: H.M. Stationery Office, 1955.) 6*s*. net.

‡ Colonial Students in Britain: a Report by PEP. Pp. ix+257. (London: PEP (Political and Economic Planning), 1955.) 21*s*.

As the PEP report on Colonial students notes, in most territories the demand for professional and technical skill is changing rapidly. Often the response to these changes is too slow and development is impeded because people with the right qualifications are not available at the right time. Students arriving in Britain are not always as well informed as they should be about these changes, and PEP rightly stresses the importance of systematic efforts to advise students and parents as to vocational suitability and opportunities.

This is one of the most important functions of the student advisory service which PEP recommends should be set up in each territory. Too many Colonial students reach Britain inadequately prepared and ill-equipped for their studies; but the student advisory service should not be concerned with the routine inquiries which all educational institutions in Britain are bound to make about all candidates for admission. PEP deprecates the students leaving home until they have obtained at least the minimum qualifications they require for the courses they propose to take overseas, and urges that the maximum advantage should be taken of local facilities for higher education; nor should students proceed overseas before they have received admission to an educational institution. The local student advisory service should make a continuous review of students' affairs and problems, and there should be a corresponding service in Britain to advise and help to place Colonial students. Moreover, the British Council facilities should no longer be restricted to students recommended by governments but should be available to all Colonial students.

There are other sensible suggestions dealing with such matters as short preparatory courses for the less-mature students and the provision of accommodation; but the vital issue is made abundantly plain—more careful selection by the Colonial authorities and further preparation on the part of the student. It is here above all that the recommendations are linked with the findings of the Royal Commission on East Africa and the observations of the Inter-University Council for Higher Education Overseas. On one hand, they imply greater local efforts to provide adequate secondary and technical education up to sixth-form standard or its equivalent. On the other, they confirm the wisdom of developing Colonial universities, where ideally the sorting process could be effected so that mainly postgraduate students could be sent on for further training or specialized work—a development itself retarded by the slow development of secondary education in both quality and quantity in the territories these institutions serve.

As the PEP report remarks, the increased flow of Colonial students to Britain since the Second World War reflects the fact that, although the facilities for higher education and specialized training in many Colonial territories have been very greatly extended in recent years, the advance has not been able to keep pace with the rapidly growing demand for trained men and women created by the accelerated tempo of local political, social and economic development. Nor is it easy to see how, without grave detriment to standards or imposing excessive demands on the limited scientific man-power of Britain generally, as well as on the universities, the young institutions in the Colonies can be expanded rapidly to overtake that demand. Apart altogether from the fact that it is improbable certain types of education and training will be obtainable in these territories in the foreseeable future, the flow of students from the Colonial territories to Britain and some other countries is unlikely to diminish significantly for many years to come.

The relatively small number of Colonial students who are gaining the advantage of higher education and specialized training in Britain must thus bear early, and to a large extent, the responsibilities of leadership in the swiftly developing countries from which they come. Their attitude to, and relations with, Britain will be greatly influenced by their reception and experience as students in Britain. This is a paramount reason for attention to the sensible recommendations which the PEP report makes in regard to their welfare, and for the co-operation of the recognized professional associations and other bodies in the ways that are indicated.

But it is in the context of the expansion of the institutions of higher education in the Colonies that the Inter-University Council has some wise comments that need stressing. Noting that the progressive achievements in the provision of universities within the overseas territories during the past nine years have exceeded expectations, the Council remarks that the apparent ease with which the programme has been carried through to this point masks risks and dangers that may yet defeat or imperil the whole enterprise. One such danger—the growing signs of a demand for the establishment of more universities in the immediate future—bears particularly on this recommendation of the PEP group regarding the sorting out of students in the territory from which they come.

There may be political reasons for desiring a further university in a particular territory; but the consequence of such a step in a country where educational needs for the next decade might be better served by the provision of technical colleges could well be a dissipation of effort and resources, resulting in two starved institutions and a disastrous lowering of standards, not only in the so-called universities but equally in the public services and professions. The Inter-University Council and the PEP Group are at one in stressing the need for high standards and for resisting pressures to lower them. Political factors cannot indeed be ignored: local pride and support are vital to the success of any university, and it will always be a matter of delicate judgment to decide what weight should be given to political arguments when these conflict with technical and professional considerations.

Provided the academic issues and financial implications are fully and clearly stated, however, as the Inter-University Council seeks to ensure, there is the less risk either of a false step or of failure to keep alive the dynamic factors in the development of the overseas universities. The

importance of that factor—of recognizing that the new universities are communities of men and women with pride and ambition in their subjects and in their institutions—is implicit in the PEP report and also in that from the Inter-University Council. Both reports present a great challenge, not only to all directly concerned in the enterprises which they survey but also to the body of informed opinion in Britain which already appreciates how much is at stake, and how simple are some of the measures required to avoid waste of effort and frustration. Confidence and co-operation must take the place of distrust and suspicion towards Britain that endanger the political, economic and social development of the Colonial territories, and the ultimate evolution of self-governing States within the Commonwealth, which are the declared aims of British Colonial policy. An important step to meet that challenge is offered by the material collected in "The Colonial Territories, 1954–55" and elsewhere for the creation of an informed public opinion, alive to the responsibilities of Britain in those territories and sensitive to the needs of those peoples, whether they remain in their own territories, or seek to fit themselves in Britain to serve their countrymen.

LOW-TEMPERATURE PHYSICS

Progress in Low Temperature Physics

Edited by Prof. C. J. Gorter. (Series in Physics.) Pp. xii+418. (Amsterdam: North-Holland Publishing Company, 1955.) 30.50 guilders; 61*s.*; 8 dollars.

DURING the past ten years or so, the commercial availability of the Collins cryostat has enabled many new laboratories, particularly in the United States, but also in France, India, Japan and elsewhere, to work at liquid-helium temperatures, previously a monopoly of only a few specialized laboratories; and there has been, in consequence, an enormous expansion of activity in low-temperature physics. The appearance of this collection of review articles—about half from laboratories which have only recently entered the field—is therefore to be welcomed. Such review articles enable the research worker specializing in any one branch of low-temperature physics to keep up with progress in others without having to read all the original literature; because many of the principles and techniques are common to all branches, this may well give him new ideas for his own special problem as well as broadening his outlook.

The best method of presenting a review article depends very much on the nature and scope of the subject. For a rather limited topic, it is possible to give a critical survey of the experimental and theoretical situation, using tables and illustrative graphs with full references to the literature, in quite a short space. An admirable example of this style of treatment is E. F. Hammel's article on liquid helium-3, which guides the reader through a very tangled situation and shows just what has been achieved. A less-successful example is C. F. Squire's article on the effect of stress on superconductivity—an even more limited topic, but not sufficiently systematically presented and lacking an adequate theoretical discussion. At the other extreme there is the much wider topic, such as the technique of adiabatic demagnetization and its many applications, which demands a much larger space if coverage in full detail is to be achieved. This approach has been adopted by D. de Klerk and M. J. Steenland, whose article on adiabatic demagnetization is the longest in the book (62 pages) and almost a monograph in its own right; it can be read with profit by anyone who wishes to learn the subject in detail from the beginning, but is perhaps unnecessarily detailed for the low-temperature physicist to whom the book is primarily addressed. Alternatively, this kind of topic can be treated in more general terms with no attempt at a complete build-up but with a selection of illustrative examples; this is A. H. Cooke's approach in his interesting 20-page review on paramagnetic crystals in use at low temperatures. Probably the ideal lies between the two, assuming rather more specialized theoretical knowledge than de Klerk and Steenland but giving a rather more detailed development than Cooke.

Nearly all the articles are reviews of already published work; but R. P. Feynman's article on the application of quantum mechanics to the liquid-helium problem deserves special mention as being not so much a review as an original contribution, in which he presents important new developments of his recent ideas, in a form assimilable by the experimental physicist. These new ideas stress the importance of turbulence in the flow of liquid helium and are particularly suggestive for new experiments.

The eighteen articles cover a wide variety of subjects; about half are concerned with the properties of liquid helium and superconductors, and the remainder deal with paramagnetism, antiferromagnetism, ferromagnetism, propagation of sound, and transport properties of gases. There is some overlapping (between B. Serin's article on superconducting critical fields and J. G. Daunt's on electronic specific heats of metals, which might well have been combined) and the choice of detailed topics seems a little haphazard. It is, however, explained in the editorial preface that this choice has been governed partly by expediency (where the competent authority was not available to deal with a particular topic at the time) and partly by the existence of recent review articles on some topics which it seemed unnecessary to treat again for a while.

On the whole, the articles are successful in achieving their object, and it is to be hoped that the valuable service rendered by this collection of articles will be continued in at least a second volume. Perhaps, however, in such a second volume the editor might aim at rather greater uniformity in the scope and level of treatment of the articles.

D. Shoenberg

FRUIT PRODUCTION

The Fruit Year Book, 1955

(No. 8.) Edited by P. M. Synge and Lanning Roper. Pp. 142+30 plates. (London: Royal Horticultural Society, 1954.) 10*s.*; 1.65 dollars.

ALTHOUGH the cultivation of fruit trees in the specialized sense began early in the past century, so much new knowledge of its problems and potentialities comes with each year that a year-book is necessary to record the progress. The complexities of the situation are well portrayed in the present

volume in a paper on the maintenance of healthy fruit clones, by R. V. Harris. Dealing particularly with a nuclear stock organization for the propagation of tested healthy material, he shows that many fruit trees and plants harbour 'latent' viruses without showing symptoms. Strawberries have a high degree of tolerance in that they show little diminution of vigour when viruses are carried without causing symptoms. Raspberries and probably some tree fruits, on the other hand, often make but poor growth when 'latent' viruses are present—a previously unsuspected cause of lack of vigour. Absence of symptoms makes it impossible to maintain health by roguing alone; hence the necessity for a carefully controlled system of virus testing, the assessment of varietal reactions, and propagation under conditions where virus cannot be re-introduced.

D. W. Greenham describes several types of soil management for the fruit grower, from clean cultivation to permanent grass. He concludes that a suitable stand of grass and clover, mown frequently with a gang-machine, is in most cases the best form of soil management for English orchards. Straw mulches for soft fruit are also discussed; they are relatively non-absorbent, and appear to act as 'non-return valves' for the rainfall, and thereby conserve soil moisture, with considerable practical benefit.

Tree fruit yields fluctuate notoriously; A. P. Preston finds that thinning the fruits to one per twenty leaves gives good and regular crops. L. C. Luckwill shows that thinning on the large scale can be accomplished by spraying with α-naphthalene acetic acid in concentrations ranging from 5 to 50 parts per million, depending on the variety, the time after petal-fall, the degree of thinning required, the temperature, and the nutritional status of the tree. He also discusses the now well-established use of the same substance for reducing fruit drops at various times. Changes in the orchard insect fauna during the present century are reviewed by A. M. Massee, who makes a plea for their ecological study as a whole. There are several other articles of more general or regional interest, and the excellent plates add lustre to a well-produced volume.

JOHN GRAINGER

HUMAN BIOLOGY FOR THE MASSES

Life, the Great Adventure

By Jean Rostand. (Discussions with Paul Bodin.) Translated by Alan Houghton Brodrick. Pp. 258. (London: Hutchinson's Scientific and Technical Publications, 1955.) 12*s*. 6*d*. net.

THIS book is an account of a series of conversations on the French broadcasting system, which took place between Jean Rostand, a well-known French biologist and, like his famous father, a man of letters, and Paul Bodin, a distinguished poet, novelist, journalist and man of science. In the talks, Bodin played the part of a devil's advocate who was not ill-informed on matters which excite public interest, while Rostand attempted to put the point of view of a modern biologist-philosopher on topics concerned with heredity, sex, health and the future of mankind. The radio talks were listened to by a large audience and have now been expanded by Rostand and Bodin into a book which is an admirable guide for those who wish to explore some of the broader paths in the field of current biology. Translation from the French has been made by A. H. Brodrick, himself well known for his contributions to the popularizing of science.

With Rostand's general point of view few modern biologists would quarrel, although his explanation of reasons for superfluous hair in the male is nonsense. Nor is he to be commended for the most obvious side-stepping of a question from Bodin dealing with birth control; perhaps, in France, the question should never have been put. This may also explain why a subject like miscegenation is dismissed in a sentence, although possibly here the translation may be at fault.

These, however, are trivial criticisms of a book which could reach many readers. Many of them will be shocked to learn that, in days of popular education and in a country like France, whose people are so proud of their ability to behave rationally, there are still about 3,460 astrologer-palmists in Paris alone. Here the man of science has cause to regret that the spread of scientific knowledge may even increase the credulity of those who possess a little scientific learning. One of the lessons from this book is that the mass of people are still prepared to believe anything, particularly if the new cult is served persuasively with the right amount of scientific jargon. Rostand and Bodin deserve praise for their efforts to remove some of the superstitions of 1955.

T. H. HAWKINS

HISTORY OF ASTRONOMY

The History of Astronomy

By Prof. Giorgio Abetti. (Translated from the Italian "Storia dell' Astronomia" by Betty Burr Abetti.) Pp. xviii+345+34 plates. (London: Sidgwick and Jackson, Ltd., 1954.) 25*s*. net.

IN this book of more than three hundred pages Prof. G. Abetti gives the reader a straightforward summary of the history of astronomy. As he remarks in the preface, a book of this size "can be nothing but a summary of the vast amount of material which only a complete history could adequately present". He considers (Chapter 2) that the subject "may be arranged into three great periods corresponding to the history and civilization of the peoples of the Earth". First we have ancient astronomy, which can be traced back to about forty centuries before Christ and which can be considered to have ended with the decline of the Alexandrian school at about A.D. 650. Then comes medieval astronomy, which is mainly the astronomy of the Arabs and, to a small extent, that of the Romans. "But," comments Prof. Abetti, "the astronomy of these peoples, as also of the western Latins until Copernicus, is essentially nothing but a repetition of the Almagest of Ptolemy." Medieval astronomy is regarded by the author as extending up to about A.D. 1500. Between it and modern astronomy there is a transitional period of reformation, represented by the work of Copernicus, Tycho Brahe, Kepler, Galileo and Newton: "Through the work of these great men astronomy was launched on new and unthought-of paths to numerous and important conquests".

The modern era is considered to begin directly after Newton, and the book proceeds forward right up to the present day, Chapter 19 dealing with the

developments of the twentieth century. It is always extremely difficult to include contemporary developments in writing a history of anything, and the author has wisely stated explicitly that his aim here is "to give an over-all glance at the results obtained in relatively recent times up to the present, without pretending to give the complete picture either of the subject matter or of the persons". Most readers will agree that Prof. Abetti has discharged this part of his task competently and fairly, and that the book would not have been so good, as it undoubtedly is, if Chapter 19 had been omitted. Any would-be critic will be well advised to ask himself whether he could do the job better.

In the chapters dealing with ancient astronomy, many readers will select Chapter 5 as the most interesting. This chapter gives an account of the school of Alexandria. A valuable feature is an earlier chapter, "Ancient Astronomers other than Greek", which deals successively with the astronomy of the Mesopotamians, the peoples of Central America, the Egyptians, the Jews, the Phœnicians, the Hindus and the Chinese. The last two come in for some courteous but definite 'debunking'.

The author explains in the preface that this "History", now translated for English-speaking readers, was written originally in Italian and that he has "lingered more, in the course of its development, on the Italian personalities and on their contributions to astronomical progress". I consider that Prof. Abetti's 'lingerings' have enhanced the value of the book. I particularly enjoyed the author's 'lingerings' over the work and careers of Toscanelli and of Secchi. The author is probably correct in claiming that the first period of the rise and development of astrophysics closed with the death of Ricco in 1910. The fact is that the contributions of Italians to astronomy are not so well known as they ought to be, and the 'lingerings' come as a useful corrective to English-speaking readers.

The book is excellently illustrated. There is a foreword by the Astronomer Royal, Sir Harold Spencer Jones, and an appendix dealing with the development and aims of the astronomical observatories of the world.

W. M. H. Greaves

"INDEX GENERALIS"

Index Generalis

Vingt-et-unième Année, 1954–1955. (Annuaire Général des Universités et des Grandes Écoles—Académies — Archives — Bibliothèques — Instituts Scientifiques—Jardins Botaniques et Zoologiques—Musées—Observatoires—Sociétés Savantes.) Pp. xvi+2108+xx. (Paris : Dunod, 1955.) 9,500 francs.

THE "Index Generalis" first appeared in 1920 and by 1939 was a well-established work of reference, having run through a number of editions. Naturally, the Second World War seriously interrupted its publication, and it was not until 1953 that a new edition could be produced. This latest edition is based on the 1953 one with considerable corrections and additions, which make two hundred and fifty pages more of material to the already formidable total of two thousand.

The work is divided into six sections : universities and other major teaching establishments ; observatories ; libraries and archives ; scientific institutes and research centres ; academic and learned societies ; and indexes. The section on universities is by far the largest, comprising more than a thousand pages. It is arranged alphabetically by countries, and within each country by the capital city followed by other cities and towns in alphabetical order. (The principal exception to this lay-out is the entry for the United States, where the sequence is by name of university institution.) For each university a list is given of professorial staff and similar persons holding senior appointments.

The section on observatories is a comparatively small one of sixty-five pages, the entries for each observatory indicating its exact geographical position, staff, publications, instruments and work. The section on libraries comprises 171 pages, sub-divided by countries. To economize in space, twenty-five code letters, or combination of letters, are used for specifying particular items—for example, the number of books held—in the details given for each library. The section on scientific institutes, 114 pages long, has a similar but much smaller code ; but this code is not often used as the type of information given varies very much from one institute to another. The section on learned societies, which has 91 pages, is different from all the others in that it is grouped by subjects rather than by nations. Thus, under "Generalités", defined as societies with more than two subjects of study, are to be found the Royal Society and the British Academy, while in a completely different part of the section, under "Sciences (generalités)" are to be found the Royal Institution, the British Association and a host of other societies such as the Royal Aeronautical Society and the Institute of Petroleum. This only serves to show that science cannot be divided into watertight compartments, and scientific societies less so ; the arrangement by nations, as in all the other sections of the book, would have been much more preferable.

Then there are the two indexes. That dealing with names has more than a hundred thousand entries and can only be described as a 'monumental' compilation. Following each page reference is a number ranging from one to eight, which indicates the part of the page in which the name is to be found ; this is a great convenience, because many pages have dozens of names scattered over them. For some reason best known to the compilers, the lists for names beginning with *A*, *B* and *C* have short supplementary lists added at the end. The geographical index, a mere thirty-four pages compared with the three hundred and fifty pages of names, is arranged alphabetically by place-names, and then under each place are the various bodies to be found there. The main criticism to be made is that it is sometimes difficult to find a particular institution, especially if it is an American one ; one has to take the various cities in turn—New York, Chicago, etc.—and search through the numerous entries thereunder. Finally, mention must be made of the sixty-four pages at the end of the book, on coloured paper and separately numbered, which contain material that was sent in to the publishers after the main body of the book had gone to press.

The whole work is primarily in French ; but this should present no difficulty to the English-speaking reader with a smattering of French. In general, it can be said that in the past this book has been a useful work of reference, and the present edition worthily carries on that tradition.

STRUCTURE OF VITAMIN B_{12}

The Crystal Structure of the Hexacarboxylic Acid derived from B_{12} and the Molecular Structure of the Vitamin

THE hexacarboxylic acid isolated from vitamin B_{12} by Cannon, Johnson and Todd[1,2] has proved remarkably amenable to direct X-ray analysis. Through a series of calculations of successive degrees of approximation to the correct electron density distribution, we have reached a solution of the crystal structure of this product which appears to provide the solution also of a large part of the chemical structure of vitamin B_{12}.

The rapid progress which we have made has been possible through the use of the National Bureau of Standards western automatic computer (SWAC) in Los Angeles, to calculate the necessary structure factors and three-dimensional Fourier syntheses[3]. Our general method has been to compute structure factors for all observed X-ray reflexions based on gradually increasing groups of acceptable atomic positions, to assign phases to the observed structure factors after each set of calculations and to use the rephased terms to recalculate the three-dimensional electron density distribution. This in turn was employed to revise or add atomic positions.

The starting point of the present calculations was the recognition, described earlier[2], in the first electron density maps calculated for this material (using phases based on known cobalt atom contributions alone) of an internal nucleus surrounding the cobalt atom similar to that found in vitamin B_{12} itself. Structure factors were next calculated based on 62 atoms belonging to this nucleus and to the rest of the cobalt co-ordination group. In the resulting electron density distribution there was an enormous improvement in the character of the peak pattern. In addition to the 26 atoms placed by calculation, which had peak heights from 7·5 *e.*/A.^{3} upwards, 91 independent peaks appeared with heights varying from 1·6 to 4·5 *e.*/A.^{3}. All those greater than 2·5 *e.*/A.^{3}, 28 in number, were in chemically reasonable sites to be assigned to atoms of side-chains attached to the main nucleus. A further ten atoms in additional side-chains were readily recognized in two following rounds of calculation. In one side-chain alone the selection of the positions of the atoms has not been straightforward and still presents certain difficulties. Since we have little doubt from other evidence of the chemical nature of these remaining atoms, we have included them with the rest of the molecule in Figs. 1 and 2, which show the most recently derived atomic positions projected on to the crystallographic *a* and *c* planes. At the latest stage of structure factor calculations based on 73 atoms in the crystal unit the agreement factor was 28·7 per cent. This figure, while it provides no guarantee that our solution is quite correct, compares not unfavourably with values often obtained for far simpler crystals built of molecules of chemically well-established structure. Interatomic distances conform with accepted values within 0·2 A., electron densities within about 1·5 *e.*/A.^{3}.

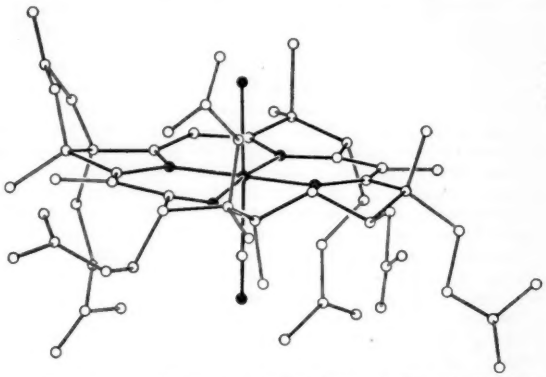


Fig. 2. Atomic positions found in the hexacarboxylic acid projected on the *c* plane. The chemical bonding deduced is outlined to emphasize the stereochemical form of the molecule

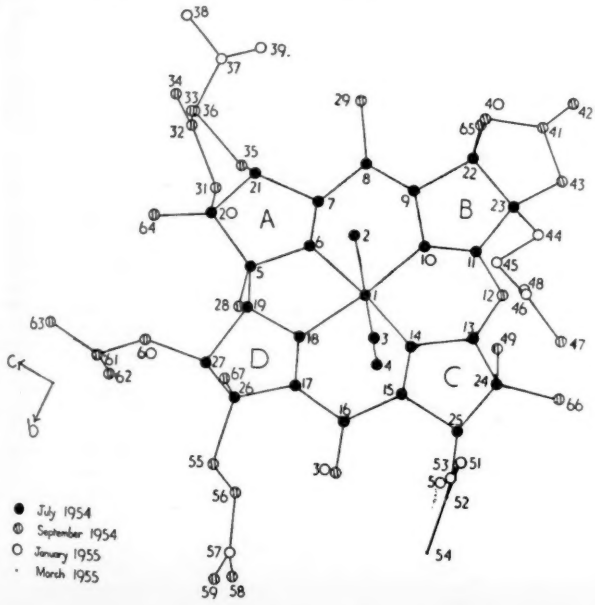
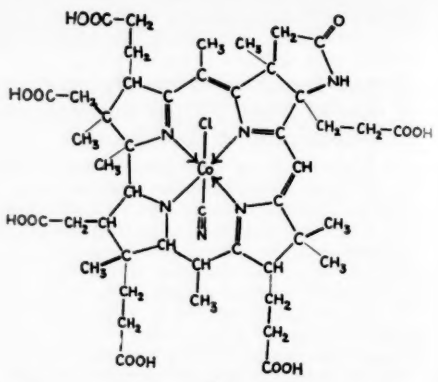


Fig. 1. Atomic positions found in the hexacarboxylic acid derived from vitamin B_{12} projected on the *a* plane. The shading illustrates the course of the crystallographic study; the dates show approximately when each group of atoms was selected

The projected atomic positions of Figs. 1 and 2 correspond with a molecule having cobalt as its centre, attached to chlorine on one side and a cyanide group on the other, and surrounded by a nucleus of 63 atoms, not counting hydrogen. Two water molecules and one acetone molecule also appear in the crystal asymmetric unit. We earlier described the inner nucleus of atoms surrounding the cobalt atom, which consists of four five-membered rings, two

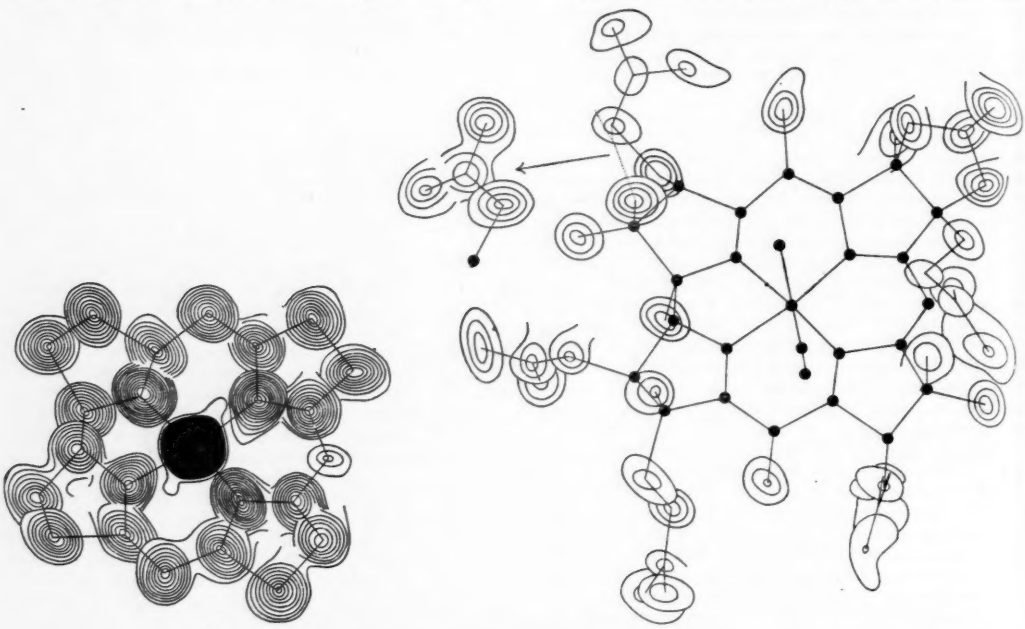
of which are directly linked. The geometrical form of this nucleus is now much clearer. The inner ring of atoms, from 6 to 17 in Fig. 1, lie closely in one plane, suggesting that they are linked by a system of double bonds. At the direct link *C*5 is tetrahedral and bears a single substituent atom. The outer ring of atoms, the β-positions of the five-membered rings, lie alternately above and below the plane of the inner ring. They are clearly reduced and carry substituent side-chains conforming in outline with substituted acetic and propionic acid side-chains, in the order characteristic of porphyrins of Type III, together with other single substituent atoms. All the acetic acid residues project on the same side of the ring as the chlorine atom; all the propionic acid chains on the other (Fig. 2). Even without the apparent porphyrin relationship, it would be reasonable to write the chemical nature of the atoms N, C and O in a major part of the skeleton formula I, following evidence of the geometrical distribution in space of the side-chain atoms and the relatively heavy electron density of the four inner nitrogen atoms and of many of the carboxyl oxygen atoms, as shown by Figs. 3 and 4. The chemical character of the single substituent atoms at different points on the nucleus is less certain from crystallographic evidence alone. Interatomic distances and relative weights are consistent with their all being methyl groups as suggested by the analytical evidence; but neither measurement is sufficiently precise by itself to exclude the possibility that one or other (and particularly perhaps 28 or 30) is a hydroxyl- or amino-group. The one exception is atom 43, which is combined in a ring. This atom from its electron density must be oxygen or nitrogen



(I)

(as NH), the ring being either a lactone or lactam ring. Neither the position nor number of the double bonds is certain; the system shown in formula I, perhaps extended by one double bond, seems most likely; but the alternative, formula III, is also possible.

To be able to write down a chemical structure very largely from purely crystallographic evidence on the arrangement of atoms in space—and the chemical structure of a quite formidably large molecule at that—is for any crystallographer something of a dream-like situation. We realize that our methods do not permit us to be dogmatic about any particular detail of our proposal formula, however much we may believe that it does as a whole correspond with reality. Our conclusions are strengthened by chemical



(*a*) (*b*)

Fig. 3. Electron density-levels and the selection of atomic positions from the three-dimensional distribution calculated with terms phased on 26 atoms

In this and the succeeding diagram, contours are drawn in the sections of the calculated distribution parallel with the *a* plane passing at or near the atomic positions. Owing to the complexity of the molecule and overlapping of atoms in projection, the complete contours for every atom are not shown. Interval of contours, 1e./A.². The figures are divided into two parts to show the atoms of (*a*) the nucleus, (*b*) the side-chains. The acetic acid residue inset in Fig. 4 is viewed along the *b* axis

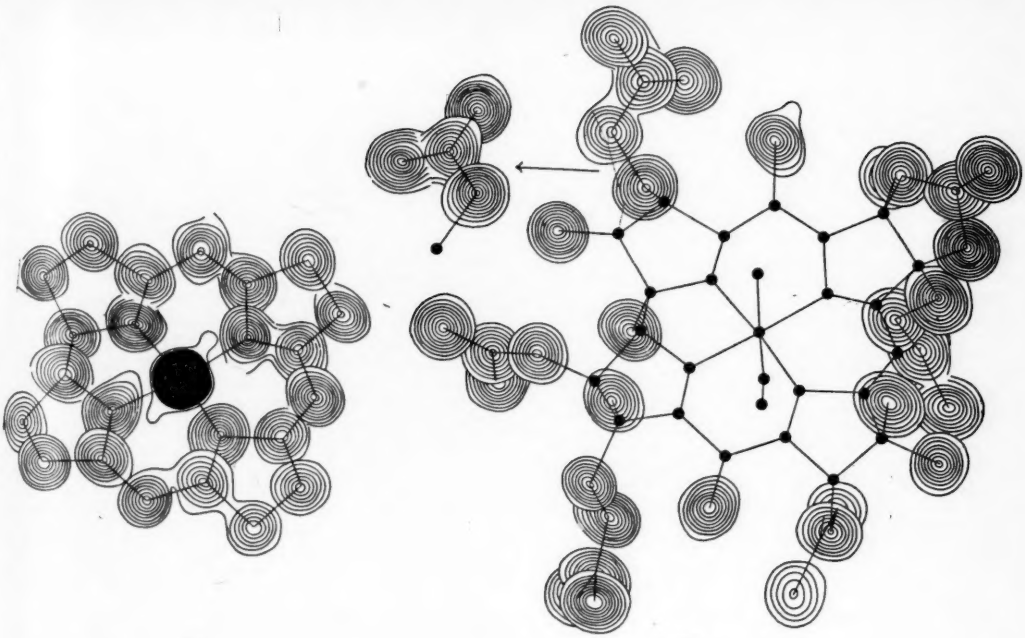
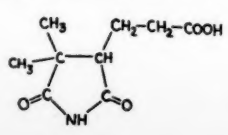


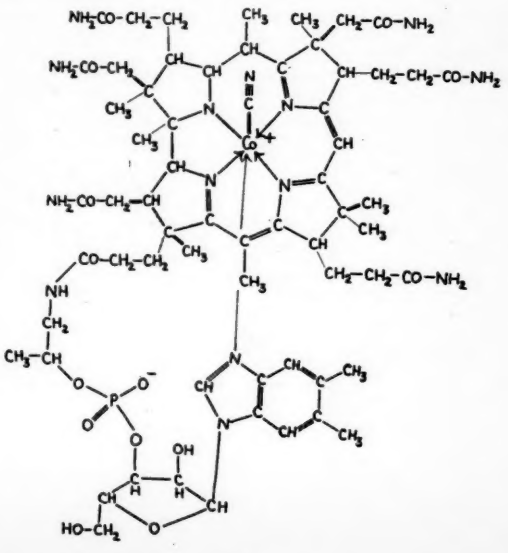
Fig. 4. Electron density-levels in the three-dimensional distribution calculated with terms phased on 68 atoms. In this and the preceding diagram it is noticeable that electron densities are usually lowest over the terminal atoms of the propionic acid side-chains owing to the greater freedom of displacement of the longer chains from their mean positions in the crystal. The effects are most marked over the side-chain on ring *C*

evidence on the nature of the degradation products already isolated from vitamin B_{12}[4] and discussed in detail below, and by our own parallel work on the vitamin itself. This additional evidence, and particularly the isolation of the succinimide, II, in the Merck Laboratories[5], was most useful in deciding the nature of the only side-chain of which the atomic positions were not immediately clear from the crystal structure of the hexacarboxylic acid.

The X-ray analysis of the different B_{12} crystals is not as far advanced as that of this degradation product, and full results on these must come later. But already we have substantial confirmation for the presence of a nucleus of the above form in B_{12} provided that an exchange reaction has occurred in the formation of the degradation product; the nucleotide in B_{12} occupies the site of the CN group in the fragment. We can also trace the positions of the atoms of the propanolamine group linking the phosphate group in B_{12} to the propionic acid side-chain of ring *D* above; only this group and the ribose molecule are directly attached to the phosphate[6]. We can observe in B_{12} no evidence of an atom at the site of atom 43 in the hexacarboxylic acid; instead, there is low electron density corresponding to a free acetamide group[7]. We conclude that the lactone or lactam ring is formed during degradation. These results make it possible to put forward a tentative complete structure for vitamin B_{12} (III). This structure corresponds to the empirical formula $C_{63}H_{90}N_{14}O_{14}PCo$ in excellent agreement with reported analyses[7] which give figures within the limits $C_{61-64}H_{84-92}N_{14}O_{13-14}PCo$. Again, the exact number and position of the double bonds are uncertain.



(II)



(III)

We are very grateful for grants from the Nuffield Foundation and the Department of Scientific and Industrial Research and for technical assistance from Mrs. U. K. Ledwith and Mrs. H. M. Oliver. We also acknowledge the support of the computer in Los Angeles by the United States Office of Naval Research and Office of Ordnance Research.

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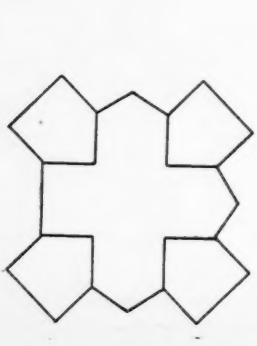
The Structure of Vitamin B_{12} and its Hexacarboxylic Acid Degradation Product

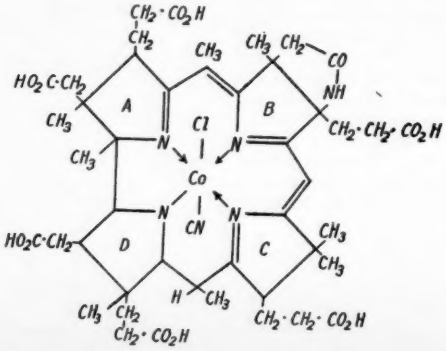
The isolation of a crystalline nucleotide-free hexacarboxylic acid from alkaline hydrolysates of vitamin B_{12} was described in an earlier communication[1], and the detailed X-ray examination of this product by our colleagues in Oxford[2] led to the recognition of the general nature of the cyclic system (I) surrounding the cobalt atom. Since that time, as described above, the relative positions of all the atoms (excluding hydrogen) in the molecule have been determined through the calculation of the full three-dimensional electron density distribution in the hexacarboxylic acid. These results, taken together with chemical evidence, have led to the proposal of the formula (II).

The crystallographic data by themselves leave open a number of details in the molecular structure of the hexacarboxylic acid, particularly the chemical nature of the single substituent atoms, the nature of the ring attached to ring *B* of the nucleus, and the exact position of the double bonds in the molecule. These can be partly resolved from chemical data. The sample of the hexacarboxylic acid subjected to chemical analysis was dried at 54°/0·05 mm. If it is assumed that the residue still contained two molecules of water of crystallization, then the formula $C_{46}H_{60}O_{12}N_6CoCl.2H_2O$ (C, 53·35; H, 6·2; N, 8·1 per cent) is in agreement with the values (C, 52·8; H, 6·3; N, 7·9 per cent) obtained from the elementary analysis. This formula differs slightly from that provisionally quoted in our previous communication[1]; but the difference is clearly within the margin of experimental error. The figures can best be accounted for by assuming that all eight single substituent atoms are present as carbon in methyl groups; it seems unlikely that any of them are oxygen or nitrogen since the mode of formation of the hexacarboxylic acid (action of 30 per cent aqueous sodium hydroxide on the vitamin at 150°) precludes the existence in it of any inherently unstable or labile groups. Independent evidence for the existence of ring *C* as now formulated was provided by the isolation and identification of the appropriate succinimide (III), from a chromic acid oxidation of a crude vitamin B_{12} hydrolysate by the Merck group[3], and we have since obtained (III) from the chromic acid oxidation of the pure hexacarboxylic acid.

The nature of the five-membered ring attached to ring *B* is the next point of ambiguity. The X-ray examination of vitamin B_{12} itself reveals that the five-membered ring, which occurs fused to ring *B* in the hexacarboxylic acid, is not present in the vitamin, which appears to contain an acetamide and a methyl group as β-substituents in ring *B* and a propionamide group as a β′-substituent. The extra ring in the hexacarboxylic acid is therefore produced by cyclization of the acetamide or acetic acid side-chain, presumably subsequent to hydroxylation at the remaining β′-position, which is activated by a carbon–nitrogen double bond, and the ring is therefore a lactam or a lactone. The hexacarboxylic acid does not acquire an additional negative charge even as high as *p*H 11, and this fact, coupled with its infrared spectrum and with the analytical figures, has led us to adopt the lactam formulation as is shown in structure (II). This aspect of the problem and its bearing on the structures of the tetra-, penta- and hepta-carboxylic acid degradation products[4] will be discussed in detail in a later paper; but it should be stressed that degradation of vitamin B_{12} to a hepta-



(I)



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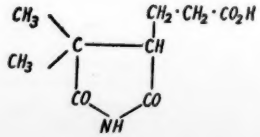
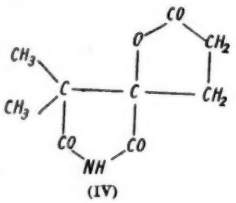


(III)

carboxylic acid without cyclization involving amide groups has only been observed in hydrolysis under acid conditions.

Hydroxylation in the activated β-positions of pyrroline rings is well established in chlorophyll derivatives[5] and occurs with ease in the vitamin B_{12} series. When vitamin B_{12} is subjected to short treatment with alkali in presence of air it is converted into a biologically inactive crystalline substance very similar to the original vitamin[6]. The oxidation involved in this conversion is, in our view, a ring-hydroxylation of the type under discussion. In support of this contention we find that the new substance, unlike vitamin B_{12}, gives no heptacarboxylic acid on acid hydrolysis, yielding instead only a mixture of penta- and hexa-carboxylic acids; on alkaline hydrolysis it is indistinguishable from the vitamin. Presumably hydroxylation will occur more readily under alkaline than acid conditions, although if a hydroxyl is already present cyclization occurs under either. It may be observed that hydroxylation of ring *C* can occur at least to some extent under acid conditions, since the Merck group isolated the optically inactive lactone (IV) from chromic acid oxidations of acid hydrolysates of vitamin B_{12}.

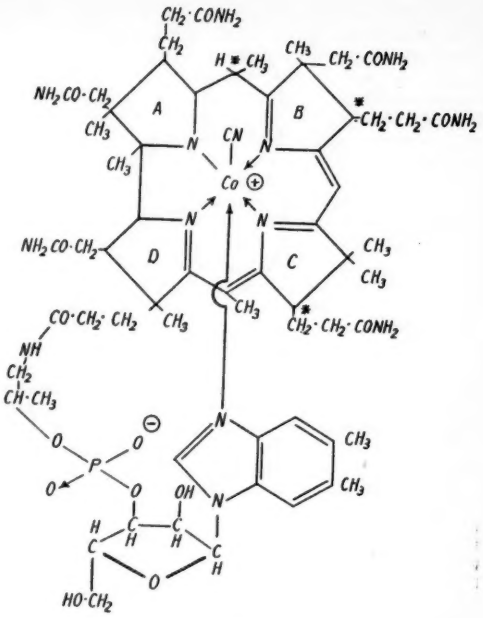


(IV)

Each of the rings *A*, *B*, *C* and *D* contains at least one tetra-substituted β-carbon atom, and consequently no pyrrole rings are present in the hexacarboxylic acid. It is therefore not surprising that there are many outstanding differences, both physical and chemical, between the vitamin B_{12} and the porphyrin series. Mention has been made elsewhere of differences in the visible spectra and of the failure to obtain maleimides from oxidations of the vitamin. From a vigorous hydrogen peroxide oxidation of the hexacarboxylic acid (II) we have isolated oxamic acid, in amounts greater than one mole per mole of vitamin. This observation lends support to structure (II) in so far as the nitrogen of the oxamic acid must originate in the nitrogen of the central partially reduced pyrrole rings. It is of interest that, whereas oxamic acid has never been reported from the oxidation of a porphyrin, it has been isolated from oxidations of hydrogenated prodigiosin[7].

The conjugated double-bond system in the hexacarboxylic acid (II) was originally proposed on the grounds that these constituent atoms of the macrocyclic ring were effectively planar on X-ray evidence. While there is as yet no definite chemical evidence for the precise location of the conjugated system, the arrangement in (II) provides an adequate explanation, not only for the production of (III) and of oxamic acid on oxidation, but also for the behaviour of the hexacarboxylic acid on chlorination, which is discussed below together with the chlorination of vitamin B_{12} itself.

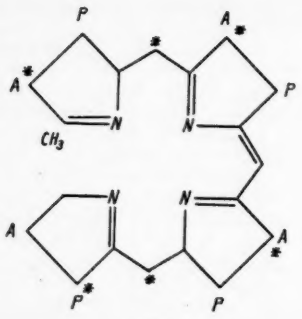
From the X-ray studies on the hexacarboxylic acid and on the different B_{12} crystals, together with considerations of its chemical behaviour, structure (V), $C_{63}H_{90}O_{14}N_{14}PCo$, is advanced for the vitamin.



(V)

According to structure (V) the vitamin contains six primary amide groups and one secondary amide joining the aminopropanol residue to the propionic acid grouping in ring *D*. It will also be observed that the vitamin is formulated as a diester of phosphoric acid, the free-acid group of the phosphate being neutralized by a positive charge on the cobalt atom. This not only accounts for the relative stability of the phosphate grouping but also for the electrophoretic behaviour of factor *B*, that is, vitamin B_{12} lacking only the nucleotide, which in contrast to the parent vitamin behaves as a monoacid base[4].

The location of the conjugated system in structure (V), although by no means proved, rests in part on the X-ray data and in part on the behaviour of the vitamin towards chlorination. On treatment of vitamin B_{12} with N-chloroamides, three moles of reagent are consumed before a stable product is formed[8], and this appears to be a dichloro compound with a visible spectrum displaced into the red. Chlorination of structure (V) would be expected to result in substitution at each of the three activated positions marked with asterisks, and only one of the chlorine atoms in the product (that on the meso-carbon between rings *A* and *B*) could be eliminated as hydrogen chloride with a consequent extension of the conjugated system; further extension of conjugation by this means is impossible. Chlorination of the hydroxylated vitamin B_{12} obtained by aerial oxidation in alkaline solution consumes, as expected, only two moles of N-chloroamide with the same change in absorption spectrum. An alteration in the location of the conjugated system in passing from vitamin B_{12} to the hexacarboxylic acid (II) apparently occurs, since the latter shows on chlorination the same behaviour as the vitamin—a fact most readily explained on the double-bond distribution shown in (II).



(VI)

Our confidence in structure (V) for vitamin B_{12} is strengthened by biogenetic considerations. It is now widely accepted that porphobilinogen, the self-condensation product of δ-aminolævulic acid, is the precursor of many porphyrins in Nature, and indeed it yields mainly uroporphyrin III on mild acid treatment. A simple scheme for the biogenesis of the vitamin B_{12} chromophore can be developed on similar lines, involving the initial formation of the tetracyclic, partially reduced, intermediate (VI; $A = CH_2COOH$, $P = CH_2CH_2COOH$). In such a molecule there are six positions (marked by asterisks) which should be susceptible to C-alkylation, and it is noteworthy that these are precisely the positions in which methyl groups occur in vitamin B_{12}. The ring-closure of the methylated (VI) to yield the chromophore we assume to occur by a dehydrogenation in the presence of cobalt; the appearance of a pyrrolidine ring in the final product is thus readily understood, as is also the double-bond arrangement. That rings *A* and *D* become linked directly rather than through the α-substituent of ring *A* (shown arbitrarily as methyl in (VI)) is probably due to steric considerations enforced by the non-planarity of the system. The introduction of the amide groups and the nucleotide portion as well as the necessary decarboxylation in ring *C* are regarded as secondary features.

Full details of the work described in this paper will be published elsewhere.

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JUBILEE OF RELATIVITY THEORY

CONFERENCE AT BERNE

ALBERT EINSTEIN published his famous first paper on relativity theory in 1905, during the time when he was employed in the Swiss Patent Office in Berne. In celebration of the jubilee of that event, a conference was held at Berne during July 11–16 this year. It was organized by a special committee of professors in the Swiss universities under the chairmanship of Prof. Wolfgang Pauli (Zurich) and with Prof. André Mercier (Berne) as secretary; Prof. Pauli also presided over the conference itself. Almost one hundred mathematicians, astronomers and physicists from some twenty different countries were present as guests of the organizing committee. They included a number of official representatives of national academies, who conveyed to their hosts the salutations of these academies on the occasion that was being celebrated. Among the guests were some who had made classical contributions to relativity theory in its earliest days and whose reputations were legendary to the younger visitors. It is only natural to make special mention of the revered personality of Prof. Max von Laue, since he was the spontaneous choice of all the other guests as the one to express their thanks at the final meeting. There were present also several of those who had been associated with Einstein in various phases of his work at Princeton.

An account of the background of the conference has already been given in *Nature* by Prof. Mercier[1]. The scientific programme was carried through in the form originally planned before Einstein's death in April of this year. The conference was officially opened by Dr. Virgile Moine, directeur de l'instruction publique (Berne), and by Prof. Pauli, who recalled Einstein's singular affection for the place where his early great work had been done. The subsequent proceedings comprised ten principal lectures, by different speakers, reviewing various departments of the subject, and about twenty short papers of a more specialized character. The committee has arranged to publish the proceedings and discussion in book form.

A programme of this nature does not lend itself to easy summarizing. However, borrowing some of the headings used by Prof. Pauli in his concluding résumé, I may record a few of my impressions.

Observational tests of general relativity. Doubts on these matters are nowadays mainly confined to the optical tests concerning the gravitational deflexion of light and the gravitational red-shift of spectral lines. The difficulties in the way of making these tests are better appreciated now than when they were first attempted. A few participants were inclined to interpret the results as establishing a definite divergence from the predictions of the theory. But the majority were prepared to accept the evidence, which was re-analysed and reviewed with due caution by Dr. R. J. Trumpler, as not contradicting the theory.

Cosmology. Much recent evidence concerning the red-shift in the spectra of external galaxies and the distance-scale of the universe was reviewed by Dr. W. Baade. This all tends to yield a value about $5{\cdot}4 \times 10^9$ years for the reciprocal of 'Hubble's constant', that is, three times the value originally estimated by Hubble; but Baade considers the uncertainty in the value to be still perhaps 20 per cent. Other speakers on various aspects of cosmology,

particularly Prof. H. P. Robertson and Mr. F. Hoyle, also discussed a wide range of observational results and astrophysical inferences that must be taken into account by the theory. Special reference was made to ways in which radio-astronomy may soon provide crucial information. Discussion on this level, as contrasted with abstract arguments about, say, cosmological principles, showed how cosmology has 'grown up' in recent years, as Prof. H. Bondi remarked. There was no violent conflict of views arising from theories depending upon unique or upon continuing creation of matter. Apparently the general attitude was that a verdict must await the outcome of further evidence of the kinds considered. But, indispensable as present theories are for giving direction to the work, certain of us expect that fresh concepts will sooner or later be needed.

Mathematical methods. Workers on relativity have gradually become aware of a number of fundamental problems involved in any mathematically adequate formulation of the subject. These are mainly boundary-value problems, topological problems and problems concerning 'global' properties of the geometries employed. It is, however, only recently that many of these problems have been given a precise formulation and solution, above all by A. Lichnerowicz[2] and his school. Prof. Lichnerowicz gave a most valuable outline of this work. Its extension to the mathematics of 'unitary' theories is in part closely related to work by Prof. P. Jordan[3], who also described his somewhat different treatment.

Extensions of relativity theory. General relativity is primarily a theory of gravitation. Ever since its invention, attempts have been made to extend it so as to deal with other phenomena and thereby to discover their physical relationship with gravitation. These attempts have followed one or other of two main ideas. The first is that general relativity, so far as it goes, is a 'geometrization' of physics, so that it ought to be possible to extend its physical scope by suitably generalizing the geometry employed. Einstein's own efforts to obtain a unified field-theory belong to this category; but he assigned a more profound significance[4] to them than do, probably, most other workers in this branch. The second idea is that any extension of the physical scope of relativity ought to depend upon relating gravitation to quantum-phenomena, and that an essential first step in this direction is to 'quantize' the gravitational field-equations. Both these approaches reduce in practice to making trial of formal mathematical procedures in the hope that relations will emerge which either admit significant physical interpretations or suggest the general character of the desired physical relations.

Much work along these lines was described by Prof. P. Bergmann, Dr. Harris-Kaufmann, Prof. O. Klein and others; but there seemed to be no claim that it has so far produced any advance in physical theory. While no one can assert that such exploration of mathematical possibilities will never suggest any physically interesting relationships, the majority of those present were pessimistic about the prospects.

At the conclusion of an address on relativistic invariance of quantum-mechanical equations, Prof. E. Wigner briefly and tentatively suggested a much more fundamental approach. He recalled that general relativity is based on the concept that only coincidences in space-time are observable and on the principle of equivalence. From the fact that the concept of coincidences is not applicable on the atomic scale, Wigner was led to suggest that the use of co-ordinates would have to be renounced in the basic formulation of a more comprehensive theory. From the fact that the principle of equivalence gives a priority to gravitational interaction which it does not possess in atomic systems, he suggested that the simplicity of gravitational interaction may be realized only in the later stages of such a theory. Wigner thus foreshadowed a theory that would not look at all like general relativity in its initial formulation but in which familiar relativistic features would emerge in the final development. His arguments carried considerable conviction and reinforced the doubts about the feasibility of proceeding in the opposite direction, that is, from relativity to something more general. However, Wigner did not try to formulate such a new theory, beyond offering a suggestion that its equations might involve derivatives of fields with respect to fields instead of derivatives with respect to co-ordinates.

In view of Einstein's death, there were appropriately added to the conference some features of a more personal and commemorative nature. Calling upon many recollections and intimate details of academic history, Prof. Max Born gave an illuminating account of Einstein's career and its impact upon the physics of its times. Also at the 'Jubiläumsfeier' in the University of Berne at the end of the conference, Prof. Louis Kollros (Zurich), in an address read by Prof. Mercier, gave memories of Einstein's time in Switzerland, with numerous little-known particulars.

It is remarkable that this was probably the first international conference ever to be devoted to relativity. As the foregoing notes should show, its attention was concentrated upon current, and often tentative, developments rather than upon established 'text-book' theory. The exchange of ideas that took place is certain to play a large part in future progress, and Prof. Pauli, Prof. Mercier and their colleagues have done a great service to the advancement of the subject.

W. H. McCrea

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THE UNIVERSITY MUSEUM, OXFORD

By Dr. WILLIAM HOLMES
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THE year 1850 might formally be regarded as marking the beginning of modern science in Oxford, for it was then that there was first established a School of Natural Science, capable of conducting its own examinations, and of awarding honours degrees.

But the year 1855 marked a more substantial advance, for in that year was laid the foundation stone of the new University Museum; in this building there were, for the first time, facilities such that the teaching of undergraduates could keep pace with the growth of science.

The University Museum has always meant more to Oxford than just an establishment in which collections are maintained; it has been, from its foundation to the present day, the centre of all

scientific research and teaching in the University. Before it was built, the fruits of collectors' enthusiasm had accumulated in several university buildings; as the collections grew in size they became less accessible, and more difficult to preserve. The records are probably not exact enough to reveal the extent of the losses that the collections suffered before the building of the new Museum. One disaster is, however, recorded and well known; it took place in 1755, when a decaying specimen, thought to be useless, was put on the bonfire. It was the last example of the dodo.

With the development of the Honour School of Natural Science it was found that the collections were essential for the teaching of undergraduates, and that they were ineffective for this purpose as they were, at that time, distributed. We should honour the men who realized that a change was necessary, and took steps to bring it about. In 1847 Daubeny, Duncan, Walker and Acland drew up a 'memorial' addressed to the University. They said: "We . . . being officially connected with various institutions for the advancement of Natural Knowledge in this University, are of opinion that the several collections . . . are deposited in rooms of inadequate dimension and inconvenient arrangement, and that their present efficiency and future progress are by these means retarded. . . . we are desirous of furthering such steps as may tend to the erection of an edifice within the precincts of the University for the better display of materials illustrative of the facts and laws of the Natural world".

There were some men of science in Oxford who saw no hope for the development of their subject: William Buckland, the geologist, was one of those who refused to subscribe to the memorandum which Daubeny and his colleagues had drafted; he wrote: "Some years ago I was sanguine, as you are now, as to the possibility of Natural History making some progress in Oxford, but I have long come to the conclusion that it is utterly hopeless—the idle part of the young men will do nothing, and the studious portion will throw their attention into the channel of honours and profits which can alone be gained by the staple subjects". The manuscript of this letter was to be seen among a collection of documents, many of them of the greatest rarity, arranged by Mr. H. F. Alexander in an exhibition in the Radcliffe Science Library, during the period of the recent centenary celebrations.

Many in Oxford appreciated the urgency of the situation, and the more optimistic view prevailed. In 1849 a body called the Oxford Museum Committee was set up, and appealed for subscriptions towards the cost of building a new Museum. In 1850 it told of what it had collected in a letter to members of the Convocation of the University: not a great deal had been subscribed. In 1852 a tremendous help came in the report of the Royal Commission: it recommended that the University should proceed with the plan for building a "Great Museum" and that the trustees of the collections of various kinds should be empowered to transfer their collections to this Museum.

The University proposed to act: the University Press had in its account a balance of £60,000, and it was moved that this should be transferred from the Press account to the General Account of the University. The money was to be used to cover several expenses beyond those of the Museum. It was an amusing and healthy habit, in those days, for senior members of the University to express their views in privately printed pamphlets, when they objected to proposals by the Hebdomadal Council. Such a pamphlet appeared on this occasion: "the proposed Museum, Lecture Rooms, and various other apartments, exceed greatly in number, and some in magnitude, the needful requirements. . . ."

The University established a body, called "The Delegates of the New University Museum", in 1854. The Delegates were empowered to invite architects to submit plans for a building; in December of that year Acland invited the University to a conversazione in the Radcliffe Library, to meet the delegates, and to see the fruits of this invitation. Thirty-two designs had been submitted by twenty-nine architects. The delegates had selected six as possibles, the styles of which were said to be: Italian, Jacobean, Palladian, Rhenish Gothic, Roman, and Belgian Gothic. The short list was Palladian and Rhenish Gothic.

Opposition was not silenced by the delegates' hospitality. "The Babylon of a new Museum is again before us. Have we any Students in Natural Science? No! Do we require this new Museum? No!" wrote one pamphleteer. Other attacks were on the final choice of design, which was for the Rhenish Gothic. Another pamphlet, thought to be by Acland himself, explained what was wrong with the Palladian: among many objections, he pointed out that it was of three floors, one of them in a basement, and that the laboratory and yard of the Physiological Department were placed within the mass of the building. In the Rhenish Gothic, on the other hand, the use of detached buildings around a central court allowed for expansion.

The Rhenish Gothic design, which was by B. Woodward, included a great deal of decorative work for which it seems that the University was disinclined to pay. For in 1856 a circular had again to be sent round, asking for private subscriptions. Shafts of different kinds of rocks were required, 124 of them at £5 each; these would be useful, as illustrations of geology; they would also be ornamental. Most expensive of the items which individuals were asked to buy were the statues of the great founders and improvers of natural philosophy. These were likely to cost £70 each in Caen stone. Her Majesty the Queen had already promised several; John Ruskin, of Denmark Hill, had offered to purchase Hippocrates, Dr. Hope the statue of Linnæus, and the bachelors and undergraduates of the University Aristotle and Cuvier.

The foundation stone of the new Museum was laid on June 20, 1855, being the day of the annual Encænia; on this occasion honorary degrees were to be conferred on Tennyson and Gladstone, among others. The night before the ceremony the Chancellor of the University, Lord Derby, spoke on the subject of the new Museum at a reception in the Radcliffe Library. This is the building now known as the Radcliffe Camera, for Dr. Radcliffe's medical and scientific library was transferred to a room in the Museum as soon as it was built. A contemporary Oxford lady said[1]: "It was long and uninteresting, and not delivered with spirit".

On the day of the ceremony there was lunch at All Souls, and *The Times* wrote: "After a very hurried luncheon . . . visitors proceeded . . . to the open ground known as 'The Parks'. The Old Hundredth Psalm was sung, Lord Derby laid the stone, and addressed the meeting at some length,

going over most of the ground which he had gone over at the Radcliffe".

On June 20, 1955, the centenary was celebrated at the same hour—by the sun's time. With equal piety but greater wit, Sir Gavin de Beer, director of the British Museum (Natural History), at the invitation of the University, gave a lecture within the walls of the Museum, to mark the occasion[2]. It was heard, with great appreciation, by the Vice-Chancellor and a large body of senior members of the University. Having surveyed the events which led to the occasion he was commemorating, Sir Gavin spoke of the growth of Oxford science in the hundred years, in the spreading group of laboratories centred on the Museum court. He named some who, working there, had made outstanding contributions: Brodie, Perkin and Sidgwick; Rolleston, Burdon Sanderson, Haldane and Sherrington; Sollas, Poulton, Geoffrey Smith, Jenkinson and Goodrich. "These masters of research set a standard of which we may justifiably be proud; and the remarkable thing is that their successors, who are fortunately still with us, have not only equalled it but surpassed it."

Looking to the future, Sir Gavin noted that the centenary by chance marks also a reorganization in the control of the collections, this change having taken place in the present year; it came about as follows.

The original building contained accommodation for seven scientific departments, as well as for Radcliffe's library. With the growth of the science faculties, new buildings were needed, and these were built at the periphery of the Museum area, on land taken from the University Parks. Since the Museum collections were useful to the teaching of science only in certain of its branches, it was inevitable that the rooms immediately adjoining the Museum court came to be reserved entirely for Departments such as those of Geology and Zoology. The collections were enriched by Dr. Hope's entomological specimens, and when, in 1861, he endowed the Hope chair of zoology (entomology) the new professor moved into the building as one concerned with material which already occupied a good deal of space. In 1883 the ethnological collection made by General Pitt-Rivers was deposited in the Museum, an annexe being built on the eastern side to accommodate it; this part of the Museum is unique, for it has its own curator. For the rest there has been no curator since 1902, and the collections have been in the care of the professors whose Departments were concerned with them. This arrangement was satisfactory so long as the professors and the members of their Departments had the time and interest necessary for them to act as 'spare-time' curators. But as the scope of science broadened, and when the time-table and the laboratories became congested, few could find time even to look after the specimens used in teaching—those which, in the Zoology Department, for example, are necessary to display the variety of animal form.

The University has this year resolved to remedy this unsatisfactory state of affairs. One member of the staff of each Department concerned with the collections has been nominated as a curator, and will serve, with representatives of the delegates of the Museum, on a committee concerned only with the collections. This committee will have the power to make independent application for funds for its work; it is to be hoped that they will be forthcoming, for much needs urgently to be done.

The new arrangement is likely to be fruitful, too, in encouraging research on the rich store of material available. In zoology, for example, it is not possible for Oxford to maintain experts on the systematics of every group of the animal kingdom. But since the appointed curator in the Zoology Department is also the lecturer in taxonomy he will be able to advise postgraduate students and visiting research workers on what can be gained from the study of the Oxford material. Also, since the most exciting progress in systematics comes now from the study of the evolutionary significance of variation, he may find, and lead others to find, new scope for experiment from the study of the material in his charge.

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NEWS and VIEWS

East African Agriculture and Forestry Research Organization:

Dr. H. H. Storey, C.M.G., F.R.S

Dr. H. H. Storey has retired from the Colonial Service on reaching the age limit. He joined the newly opened East African Agricultural Research Institute at Amani, Tanganyika, as plant pathologist in 1928, after some years of service with the South African Department of Agriculture. During 1941–46 he was occupied with war supplies, and served as chairman of the East African Industrial Research Board. During this period, important work was done on the development of a phosphatic fertilizer from the extensive rock deposits at Tororo in Uganda. In 1946 he was appointed secretary for Colonial agricultural research, and was closely connected with the formation of the Colonial Research Service. In 1948 he returned to East Africa as deputy director of the East African Agriculture and Forestry Research Organization, where his administrative ability was of much value in building up this new inter-territorial venture.

Dr. Storey has made notable contributions to agricultural research and practice. He was instrumental in identifying the devastating tea 'yellows' in Nyasaland as a sulphur deficiency, and in its spectacular cure by the simple expedient of using fertilizers, for example, sulphate of ammonia, containing sulphur. His work on the interspecific hybridization of cassava to obtain virus-resistant types is probably the most extensive piece of plant-breeding yet done on a tropical food crop. More recently, his swift organization of co-operative work on breeding rust-resistant varieties of maize is likely to protect East Africa from the ravages experienced in West Africa. Dr. Storey's outstanding contribution to virus research is undoubtedly his work on the transmission processes. His original techniques for inoculating a virus into small insects, and for trans-

ferring body fluids from one insect to another, are now used by workers on both plant and animal virus diseases. It is gratifying to learn that Dr. Storey's research work will not cease on his retirement, as he has accepted a special-appointment post at the East African Agriculture and Forestry Research Organization, and pending the arrival of Dr. E. W. Russell (see *Nature*, June 18, p. 1065) he will continue as acting director.

Dr. H. C. Pereira

Dr. Pereira, who has been appointed deputy director of the East African Agriculture and Forestry Research Organization in succession to Dr. H. H. Storey, is head of the Soil Physics Department of the Organization. After completing a research on cultivation, in association with Rothamsted Experimental Station, he joined the Colonial Agricultural Service in 1946 as a member of the Kenya coffee research team. In Kenya he studied the water relationships of coffee soils with special reference to the functions of cultivation and organic mulches in maintaining the structure and permeability of the soils and, from 1949, he took an active part in co-operative work, prior to his transfer to the East African Agriculture and Forestry Research Organization in 1952. Since then he has worked on dry-farming methods applicable to East African conditions, and has paid special attention to hydrological problems in forest, arable and ranching areas. He has successfully developed soil physical methods for laboratory and field use, in tropical conditions, and has established close relations with all territorial departments concerned in hydrology.

Applied Electricity at Bangor : Prof. M. R. Gavin, M.B.E.

Dr. M. R. Gavin, who has been appointed to the chair of applied electricity at the University College of North Wales, goes to Bangor with a valuable and varied scientific and educational experience. He graduated in mathematics and natural philosophy in the University of Glasgow in 1929, and after some years as a mathematics master in Motherwell, he joined the Research Laboratories of the General Electric Co., Ltd., in 1936. Here much of his work was concerned with high-frequency valves and circuits, which earned for him the degree of D.Sc. from Glasgow ; he was also made M.B.E. in 1945 for his research work during the Second World War. In 1947 Dr. Gavin returned to educational work as H.M. Inspector in technical education with the Scottish Education Department. In 1950 he was appointed head of the Department of Physics and Mathematics in the Birmingham College of Technology, and since 1953 he has also been vice-principal. Despite difficulties, Dr. Gavin has moulded a flourishing research group in Birmingham working mainly on problems in the fields of electronics and semiconductors, and has introduced new postgraduate courses on such topics as electronics, transistors, vacuum technique, X-ray technology and gamma-radiography. The Department of Applied Electricity in Bangor is concerned with the lighter branches of electrical engineering. Although the Department is independent, the relationship with physics is a close one, since there are no other engineering departments in Bangor. Dr. Gavin's blend of experience thus fits him well for this new appointment.

Nuclear Research and Development

Under the title "The Commonwealth and Nuclear Development", the Central Office of Information has produced as Reference Pamphlet No. 2 the account of the British contribution to nuclear research which the Prime Minister on June 16 promised the House of Commons would be available in time for the International Conference on the Peaceful Uses of Nuclear Energy (pp. iv+52. London : H.M.S.O. 2*s*. net). In five well-written chapters, to which are appended the United States proposals of March 19, 1954, for an international atomic energy agency, the United Nations draft resolution on co-operation in developing peaceful uses of atomic energy and a brief bibliography of Government publications, it gives a clear account in non-technical language of the development of nuclear physical theory to 1939 and the present position. There are also accounts of the development of nuclear weapons, the United Kingdom nuclear energy project, progress in other Commonwealth countries, particularly the Canadian programme and the position in Australia, and international co-operation in this field, leading to the European Organization for Nuclear Research, the European Atomic Energy Society and the latest agreements (June 15, 1955) between the United Kingdom and the United States.

Most of the information is summarized from official documents ; but among interesting new points the pamphlet emphasizes that an important factor in Britain's growing export of radioisotopes has been their reasonable price—and it may be noted that the price of some have been recently further reduced (see below). The average value of each of the 10,257 dispatches from Amersham last year was £20, and some useful items cost only £5. Exports between October 1953 and September 1954 went to forty-one countries, and to help prospective purchasers, catalogues of radioactive materials and labelled compounds giving technical details and prices are available. Some further information is provided regarding the new experimental nuclear reactors. The zero energy fast reactor ZEPHYR, which went into operation at Harwell in February 1954, will supply operating and design information of major importance for the fast breeder reactor under construction at Dounreay, while a deuterium-moderated low-energy reactor, known as DIMPLE, which started operation in August 1954, has been used for experimental work for a new and more powerful heavy-water reactor which is being built at Harwell to provide the high-neutron flux essential for some research purposes. This reactor, which should be operating in 1957, will be a powerful source of radioactive isotopes as well as testing materials. The pamphlet includes Mr. Geoffrey Lloyd's announcement of June 13 regarding the additional reactors to be built at Calder Hall and near Annam, and summarizes some details of industrial co-operation and of the training programme.

Prices of British-produced Radioisotopes

Reductions in the prices of iodine-131 and colloidal gold-198, which are distributed from the Radiochemical Centre, Amersham, are announced by the United Kingdom Atomic Energy Authority. These isotopes are used extensively for treating disorders of the thyroid gland and of the lymphatic system. The concession has been made possible by a continuing growth in demand and by improved

manufacturing efficiency at Amersham. The saving to the average isotope user will be about 20 per cent. Both these isotopes are in ample supply. Although they are short lived—iodine loses half its activity in eight days and the gold loses half its activity in three days—they can be delivered by air to any part of the world at short notice; the Radiochemical Centre provides sufficient activity to compensate for that loss during transit. Among the more distant countries already using this service are Australia, New Zealand, Argentine, Uruguay, South Africa and Japan. The new prices are: iodine-131, in carrier-free solution—a minimum charge of £1 for 1 millicurie and 3*s*. 6*d*. per millicurie thereafter; iodine-131 in sterile solution—a minimum charge of £2 for 1 millicurie and 3*s*. 6*d*. per millicurie thereafter; gold-198, in a colloidal solution—a minimum charge of £5 for 50 millicuries and 6*d*. per millicurie thereafter.

Academy of Zoology, India, and *Annals of Zoology*

In 1954 a new society, the Academy of Zoology, was founded in India, with headquarters in Agra, under the presidency of Prof. B. C. Mahendra. Its aims are to further all branches of zoology and to encourage research, not only in India, but in countries in the East in general, with as international an appeal as possible. This is indeed an ambitious project. The Academy has started a new journal, the *Annals of Zoology*, each part of which will in general consist of a single memoir; supplements containing short notes, reviews, etc., will be issued from time to time, and special volumes may also be issued. The first part, which appeared in January this year (**1**, No. 1 (1955); pp. 22; Rs. 15 or 30*s*. for each volume of approximately 240 pp.), is a paper by Surendra Sharmer and P. N. Tiku on the venous system of *Rana tigrina* Daud, a frog widely used in the universities of northern India, for which no detailed account of the veins is available. The paper is a straightforward piece of work carefully done and based upon the classical account in Gaupp's "Anatomie des Froches", which is a good model. The authors have followed Gaupp in his incorrect account of the interpretation of the relationship of the abdominal vein and hepatic portal vein. The block-making and printing are well done upon good paper, and the text is remarkably free from errors. The editor, authors and printers are to be congratulated on a satisfactory production. Inside the cover, it is stated that the Academy intends to continue the well-known series of "Indian Zoological Memoirs" established by the late Prof. K. N. Bahl, which have come to an end with his much regretted death. This would be a valuable service to zoology and to Indian zoology in particular. Information regarding the Academy and the *Annals* can be obtained from the Secretary, Academy of Zoology, 164 Civil Lines, Agra.

Air Pollution in Britain

The Clean Air Bill published on July 27 is intended to implement the principal recommendations of the report of the Beaver Committee on air pollution in Britain (London: H.M.S.O. 1*s*. net). It applies to Great Britain only, and four of its clauses prohibit the emission of dark smoke from chimneys, railway engines and vessels, subject to exemption by the Minister for specified periods to cover soot-blowing, the raking of boiler fires and other necessary operations which unavoidably cause smoke for a few minutes. It will be a defence to prove that emission of dark smoke was due solely to the lighting up of a furnace from cold, an unpreventable mechanical failure, the impracticability of obtaining suitable fuel, or (for the first seven years only) the unsatisfactory nature of the furnace and the impracticability of modifying it at reasonable cost. Clause 3 prohibits the installation of new industrial furnaces unless they are capable, so far as practicable, of being operated continuously without emitting smoke. Clauses 4–7 require the emission of grit and dust from existing industrial furnaces to be minimized, and new furnaces burning pulverized coal or large amounts of other solid fuel to be provided with grit-arresting equipment. Clause 8 empowers local authorities by Order (subject to confirmation by the Minister) to designate 'smoke-control areas' in which the emission of smoke from any chimney will constitute an offence. In such areas, grants covering at least 70 per cent of the cost of adapting or replacing grates and stoves to enable smokeless fuel to be used will be payable to owners or occupiers of private dwellings, of which 40 per cent will be paid by the Government and at least 30 per cent by the local authority. The cost of these clauses to the Exchequer is not expected to exceed £3 million a year, but expenditure up to £40,000 will be incurred by the appointment of additional staff by the Ministry of Housing and Local Government and the Department of Health for Scotland.

Forestry in Malaya

In spite of all the troubles in Malaya, which must have made forestry working exceptionally difficult during the past few years, the *Malayan Forester* (**17**, No. 1; January 1955) maintains its high character. The number includes several papers presented to the Fourth World Forestry Congress held last December in Dehra Dun, India. One, on Malayan tropical rain forest, by F. H. Landon, is of exceptional interest. An important note is struck in the editorial on the housing question, which is as vital in many parts of Malaya as in Britain. In the past, the houses were built mainly of unseasoned timber and classified as 'temporary' or 'semi-permanent'. Only unseasoned wood was obtainable, and the timber trade made no effort to provide the public with seasoned wood. Now houses are built of brick and cement, tiles and metal windows, though there is an abundance of timber in the forests of the country which only requires the introduction of modern methods of seasoning to make available houses at a cheaper rate. It is scarcely a matter for surprise, then, that the Government is losing money on its forestry working.

Evidence of Translocated Antibiotics in Expressed Plant Sap

Details have been given by S. H. Crowdy and D. Pramer (*Ann. Bot.*, N.S., **19**, 79; 1955) of a convenient and efficient press for extracting laboratory samples of plant sap. The pressing procedure is stated to release 53–74 per cent of the total water as expressed sap. They have also described briefly some preliminary experiments on the uptake and translocation of antibiotics. They have shown that the assay of expressed sap provides a measure of the griseofulvin and chloramphenicol concentrations in leaves of plants grown in solutions of these antibiotics, that is, in good agreement with the values obtained by the assay of water extracts. By using organic solvents, however, the authors have extracted considerably greater amounts of antibiotics than is

indicated by the assay of expressed sap. To explain this difference they have postulated the existence of a 'free' antibiotic fraction, which is obtained in water extracts or in expressed sap, and a 'bound' fraction which can be recovered from the leaf only by using suitable organic solvents.

C. L. Herrick

The whole of a recent issue of the *Transactions of the American Philosophical Society* is devoted to an account of the astonishing life of the famous American naturalist and psychobiologist, Clarence Luther Herrick (**45**, Part 1 ; 1955). The author is his younger brother, Prof. C. J. Herrick, who writes with great pride and affection of his brother's career when holding chairs at Denison University and the Universities of Cincinnati and Chicago, his posts as United States deputy mineral surveyor and president of the University of New Mexico, and manager of the Cat Mountain Mine in New Mexico which soon became bankrupt. All this was crowded into a life of forty-six years, the last eleven of which consisted of a struggle against pulmonary tuberculosis. His brother describes him as a precocious genius "whose pioneering was in areas of remarkable diversity—in natural history surveys, in geology and paleontology, in general biology and ecology, in comparative neurology and psychology, in rare proficiency as an inspiring teacher and educational administrator, in the rejuvenation and successful reorganization of a great university, in naturalistic philosophy, and in the founding of two great scientific journals".

Abstracts of New Zealand Scientific Papers

Last year a new feature was started in the *New Zealand Science Review*, the official journal of the New Zealand Association of Scientists, whereby abstracts were prepared of scientific papers published in New Zealand since September 1, 1953, and, where possible, of papers published in Britain or North America which were based on work in New Zealand. By the end of the year, 502 such abstracts, covering the period up to October 30, 1954, had been printed, and in the November–December number of the *Review* (**12**, Nos. 11–12 ; 1954) are to be found author and subject indexes for all these abstracts ; the subject index is particularly full and contains nearly two thousand entries. The abstracts are arranged under subject headings, and biological and agricultural subjects, as befits a country like New Zealand, greatly predominate, though entries under physical and technological subjects, etc., are to be found. It should be borne in mind, however, as a preparatory note to the subject index explains, that very little of the work in physics, chemistry or mathematics that is done in New Zealand is published in that country, and the compilers of the abstracts are fully aware that they have not covered extensively overseas journals. The onus of directing attention to their work must always rest on the authors of papers themselves.

Ramsay Memorial Fellowships for 1955–56

Ramsay Memorial fellowships for research in chemistry have been awarded for 1955–56 to the following: B. R. Hammond and E. Haslam, general British fellowships at the University of Cambridge ; H. Inokuchi, a Japanese fellowship at the University of Nottingham ; Dr. R. V. Jordana, Dr. A. Esteve and Dr. Garcia-Moliner, Spanish fellowships at the University of Cambridge ; and T. Cohen, a United States fellowship at the University of Glasgow. The following fellowships have been renewed : Dr. J. A. Davies, Canadian fellowship at the University of Leeds ; Dr. L. H. Ruiter, Netherlands fellowship at the University of Bristol ; and Dr. C. Alfonso, Spanish fellowship at the University of Birmingham.

Polish Medal Awards for Scientific Work

The following medal awards have recently been made in Poland. *Biological Sciences :* Prof. J. Dembowski, for general scientific work ; Prof. E. Mikulaszek, for his work entitled "Immunologically Active Polysaccharoses". *Mathematical and Physical Sciences :* Prof. K. Borsuk, for distinguished work in topology ; Prof. L. Infeld, for outstanding achievements in theoretical physics and, in particular, for work on the theory of gravitation and non-linear electrodynamics ; Prof. S. Pawłowski, for the discovery of sulphur deposits of great economic importance ; Prof. J. Samsonowicz, for research into depth structures of the Polish Plain.

Announcements

We regret to announce the following deaths.—Prof. R. W. Wood, For.Mem.R.S., research professor of experimental physics in Johns Hopkins University, on August 11, aged eighty-seven ; Prof. J. B. Sumner, recently professor of biochemistry and director of the Enzyme Research Laboratory in Cornell University in 1946, on August 12, aged sixty-seven.

Mr. Sidney John Worsley, principal of the College of Estate Management, Kensington, has been appointed by the Secretary of State for the Colonies to be secretary of the Inter-University Council for Higher Education Overseas and of the Colonial University Grants Advisory Committee. Mr. Worsley succeeds Dr. Walter Adams, who has been appointed director of planning and principal-designate of the University College of Rhodesia and Nyasaland (see *Nature*, January 29, p. 193).

The ninth General Assembly of the International Astronomical Union will be held in Dublin during August 29–September 5.

Dr. N. B. Chapman, senior lecturer in organic chemistry in the University of Southampton, has been appointed a reader in respect of that post.

The College of Physicians of Philadelphia has awarded the Alvarenga Prize for 1955 to Dr. C. H. Rammelkamp for his outstanding work in the field of streptococcic infections, particularly in relation to rheumatic fever and nephritis.

The following appointments in the University of London have been announced : Dr. Roger Warwick, lecturer in anatomy in the University of Manchester, to the University chair of anatomy tenable at Guy's Hospital Medical School. Dr. R. H. Gorrill, senior lecturer in bacteriology at St. Mary's Hospital Medical School, to the University readership in bacteriology tenable at Guy's Hospital Medical School.

The ninth annual conference of the Stress Analysis Group of the Institute of Physics will be held during September 28–30 in the Stephenson Hall, University of Sheffield, and will deal with applications of stress analysis. Enrolment forms and further information can be obtained from the Secretary of the Institute, 47 Belgrave Square, London, S.W.1.

BUILDING RESEARCH STATION, GARSTON, WATFORD

OPEN DAYS FOR ENGINEERS

THE purpose of the display of engineering and soil mechanics work of the Building Research Station (Department of Scientific and Industrial Research) at Garston, Watford, during July 15–19, was not so much to give a general account of work in progress as to stimulate the application of the results of research by practising civil and structural engineers. To this end, special emphasis was laid on five lines of research: those concerned with reinforced concrete, steel-framed structures, load-bearing walls, bridges and foundations.

One important contribution to research was mentioned by Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research, in opening the exhibition. Referring to the expert advice and guidance on building research given by the Building Research Board under the chairmanship of Sir Herbert Manzoni, Sir Ben said: "This Board, consisting of people of great ability, achievement and experience in the many and varied aspects of building, give us their time voluntarily and do us a service we could not obtain in any other way. All our D.S.I.R. Stations enjoy this advantage, and it is not generally known how much scientific research owes to the public-spirited men and women who serve on our Boards".

The central theme of the presentation was that the older methods of design lead to under-estimations of the strengths of structures, that more exact methods of design are being made available, and that provision is increasingly being made, in building regulations and codes of practice, for their use.

The safety factors used in structural engineering have to take into account a number of variables, such as the mechanical properties of building materials, quality of workmanship and the knowledge of designers. On the other hand, there are many ameliorative effects, such as rigidity at joints in frames, stiffening by concrete encasing steelwork, stiffening by panel fillings, and 'composite action' generally, that cannot be taken into account until a quantitative assessment of them is possible. Display panels and testing equipment were used to illustrate the Station's work on both aspects of this general design problem.

Research on reinforced concrete has led to the inclusion in the relevant code of practice (*CP* 114) of recommendations for a new method of design—the load-factor method. The principle behind this method is that the load that will just cause failure of a structure is sufficiently greater than the working load to bring the probability of failure during the working life below a specified limit. Several exhibits illustrated research to provide data enabling designers to use the load-factor method of design with safety and economy—research on the control of quality of concrete as well as on the behaviour of walls, beams and other structural components at the point of failure.

With steel-framed buildings, three main lines of investigation are leading to more economic methods of design. Mathematical analysis has been made of a large number of idealized frames with fully rigid joints, to enable the bending moments in the neighbourhood of such joints to be assessed accurately. Secondly, an attack is being made on the problem of what happens in a steel structure when some of the steel is deformed beyond its elastic limit and passes into the plastic range. Formerly, this point was regarded as marking the limit of strength of the structure; in fact, it marks the onset of a redistribution of stresses that may result in a considerable margin of safety before actual collapse occurs. Thirdly, there is the question of how much allowance can be made for the effects of composite action, in a complete building, between the steel frame and floors and panel infillings, and between the steel members and concrete encasements provided primarily for fire protection.

A major difficulty here is that of embodying this more accurate knowledge of structural behaviour in design procedures that are not too complicated for adoption by the profession as a whole. The aim, therefore, is to express the results of mathematical analysis, once their validity has been confirmed by measurement, in simple design charts that can be used with confidence by a designer even though he may not feel at home with the analytical methods that have gone into their preparation.

The thickness of load-bearing walls has in the past been largely determined by rules-of-thumb that have been shown by experience to be safe. Such rules are often wasteful. Examples were shown of work devoted to determinations of the strength of walls under various conditions of loading, so that design recommendations on a calculated-stress basis could be formulated. The results of this work, mainly on walls and piers built with bricks and blocks, largely shaped the recommendations of the code of practice (*CP* 111) for the design of load-bearing walls—recommendations that can lead to important economies in material.

Research on bridges has naturally been pursued in close liaison with the Ministry of Transport. Perhaps the most important outcome of this work has been, in a sense, an invisible one. Throughout Great Britain there are some thousands of old bridges, carrying traffic much heavier than was envisaged at the time they were built. It was thought that many of these bridges might have to be rebuilt. The Station was asked to investigate, with the view of formulating more accurate ways of assessing the strength of such bridges. From 1936 onwards more than fifty cast-iron girder and masonry arch bridges were tested, some of them being loaded to destruction. Two important conclusions emerged: first, with the girder bridges, a load applied over one girder is partially supported by other girders; secondly, with both girder and masonry arch bridges, the fill and road-surfacing material gradually becomes consolidated and acts structurally in combination with the girders or arch so as to give a total strength considerably greater than that forecast from consideration of the basic structure alone. Many suspected bridges were thereby reprieved—a matter of immense and immediate importance when, during the Second World War, it became necessary to send heavy military vehicles up and down the country. This work on old bridges alone saved the country many millions of pounds.

Since the War, research on bridges has been concerned mainly with modern steel-and-concrete bridge

decks. The most striking feature of measurements on bridges has been the low values for the strains measured in the girders, even with heavy traffic. Laboratory tests on scale-models have helped to explain this, particularly on the basis of composite action between the girders and the concrete and of the lateral distribution of load among the girders. Several possible new methods of design are being investigated, with the view of gaining all possible advantage from this structural interaction, which previously was ignored.

A working model was used in the exhibition to illustrate a series of tests that measured the dynamic effects of traffic. The impact factor (the ratio of the strain due to a load applied dynamically to that due to the same load applied statically) varied in most cases between 0·8 and 1·3, the commonest values being about unity. In the past, it has been usual to assume an impact factor of 1·5 or more for design purposes; but the tests show that such a value is unduly high and that a more economical design can be made on the safe basis of an impact factor of 1·25 or even less.

The work on bridges demonstrates *in parvo* nearly all the principles characterizing the present-day approach to the problems of designing structures above ground. Formerly the approach, in very general terms, was to reduce a structure to the simplest components that could be considered to lead an independent structural existence—joists, girders, columns, walls, slabs; the loading each component could sustain without permanent deformation was then calculated according to simple rules based on tests on such components in isolation; finally, each component was assumed to be similarly loaded in the complete structure, needing to be strong enough to support the worst probable load distribution. Any component not designed for strength was assumed to make no contribution. Nowadays, the tendency is to consider the behaviour of the complete structure, to measure stresses at critical points in buildings under construction and after completion, to account for these results by more refined theories of stress–strain pattern, and finally to interpret these theories in terms of convenient rules for design. The important thing is that investigation starts with what actually happens in actual structures.

The Building Research Station's work on foundations engineering, since it is carried on chiefly in the field, had to be demonstrated mainly by photographs. Two model-scale investigations were exhibited: in one, a glass-sided tank is used for studying the effect of seepage under hydrostatic pressure at the base of a sheet pile cofferdam; in the other, the effect is examined of proximity between piles in a group on the bearing capacity of each.

Another exhibit included part of the equipment used for measuring pore-water pressures during the construction of earth dams. Pore-water pressure tends to reduce the shear strength of the soil, with a consequent risk of instability as the height of earth fill is increased. Piezometers, incorporating a rigid porous membrane that supports the stresses due to solid material while transmitting hydrostatic pressure, are buried in the dam as work proceeds, permitting direct measurement of pore-water pressures to be made afterwards at a distance. This enables appropriate precautions to be taken if the pore-water pressure threatens to mount too high in relation to the factors contributing to stability.

LAND USE IN BRITAIN

A CONFERENCE on "Land Use in Britain" was held in the University College of the South-West at Exeter during July 15–16. It was organized by the Division for Social and International Relations of Science of the British Association, under the chairmanship of the president of the Division, Mr. P. Ritchie Calder. The Division in this way revived its pre-war function of holding occasional meetings in different parts of the country to discuss problems in which both scientific and social questions are involved. The excellence of the prepared papers and of the discussion, and the success of the conference as a whole, fully justified this initiative.

The theme of the conference was particularly appropriate at a time when most of the local planning authorities in Britain have completed their development plans, as they were charged to do under the Town and Country Planning Act of 1947.

The first speaker was Sir George Pepler, who was chief technical adviser to the Ministry of Town and Country Planning during 1943–46 and planning adviser to the Government of Singapore during 1950–54. His theme was the administrative arrangements necessary to reconcile the demands for land for many different purposes—agriculture, housing, forestry, recreation, military training, roads, airfields, etc. Sir George emphasized that at present the framing of a national policy of land use is greatly hampered by the number of government departments involved—just as at local government level planning is hampered by the number of local committees. He urged that there should be more co-operation at both central and local government levels. As soon as possible the Minister should summarize statistically the information contained in the first batch of development plans; the summaries should be reviewed and brought up to date every five years, thus producing a periodic 'balance sheet' of the land use of Great Britain.

Mr. Geoffery Clark, planning officer for Devon, then described some of the planning problems of local authorities from his own experience. Above all, he said, it was important to "take the public with you". Plans should not be imposed from above. He had found scale-models particularly helpful in explaining planning schemes to the public.

The second session of the conference considered the need of land for agriculture and forestry. Prof. L. Dudley Stamp, professor of social geography in the University of London, discussing competing uses for land, said that while in the United States there are about thirteen acres of land, including 4–5 acres of productive land, per head of population, in Great Britain there is about 0·8 acre per head, which includes about half an acre of productive farmland. The full use of our present farmland could support a little over half our population. Some 35,000 acres a year of agricultural land would probably be needed for housing, industry and other purposes during the next twenty or so years. Industry must have first priority in an industrial nation, especially as its choice of site was often determined by natural factors such as the location of mineral workings. Housing came next, and here there was considerable controversy as to desirable housing densities. It should not be forgotten that only about a fifth of the agricultural land taken for housing remained potentially productive. Further, the quality of land used should be taken into consideration. If an acre of average

land represented one 'potential production unit', then an acre of poor land would represent 0·1 unit, while one of good land would represent two units. The value of a piece of land lost to agriculture could thus vary by a factor of 20. It was therefore most important to ensure that the right land was used for the right purpose.

Sir James Turner, president of the National Farmers Union, then enlarged upon the importance of agriculture to the country. It was an unfortunate fact that the best farmland was very often also the most suitable for other purposes. Farming represented one-twentieth of the national income, and its output was now 153 per cent of the pre-war average, although the total labour force had decreased. Pursuing the question of the productivity of back gardens, Sir James said that while it might be true to say that garden produce was worth £66 per acre while farm produce was only worth £45 per acre, one must not lose sight of the fact that building houses meant building roads, schools, factories and shops as well. If this were taken into account, the value of garden produce averaged over the whole built-up area was about £20 per acre. What is more, gardens were not really replacing agricultural produce, and the proper comparison to make was with horticultural holdings, which produced about £350 per acre. The land was our only irreplaceable national asset, and once built upon was lost for ever. A coherent national policy for land use which bore this in mind was urgently required.

In the discussion, Mr. F. J. Osborne, chairman of the Town and Country Planning Association, said that increasing housing densities would not save much agricultural land. If we were to build three million houses, at fifteen houses per acre, over the next twenty years, this would use about half a million acres, or 1–1½ per cent of the remaining agricultural land of Great Britain. Increasing this density to eighteen houses per acre would not save more than 25,000 acres. To save one acre of land by building flats would cost about £20,000 in additional building costs.

The third session of the conference considered three special aspects of land use. Mr. Langley Taylor, deputy chairman of the Council for the Preservation of Rural England, said that the Cinderella of planning was amenity—not appreciated until lost; since it cannot be valued in money, it was too seldom taken into consideration. The National Parks were a step forward of great importance. Good management of forests and farmland was essential to the amenity value of the land, and here efficiency was more valuable than sentiment. We still had a long way to go before our development enhanced and did not destroy the beauty of the land.

Major L. E. Andrews from the War Office discussed the Army's needs for land for training purposes. National Service, with its greater turnover in men, modern weapons with their greater firing and manœuvring area, and modern battle training techniques had all increased the amount of land needed. About 600,000 acres of land was required for Army training; but only about 8 per cent of this land would be lost to agriculture. The Army was not in a position simply to grab land, as reports in the Press sometimes seemed to imply. The planning and agricultural authorities were always consulted, under an agreed procedure, as was the Council for the Preservation of Rural England. Usually agreement was reached; but if it was not, a public local inquiry was held, which the Army could, and sometimes did, lose.

Prof. S. H. Beaver, University College of North Staffordshire, discussed the need of land for mineral exploitation. Some 5,500 acres a year were used for this purpose at present, but by no means all of it was permanently lost to agriculture, and some of it could also be built on afterwards. Lower-value minerals like chalk, clay and gravel, which were widespread in occurrence, had to be mined where demand and transport costs made it most economic. There had been much progress recently in land reclamation methods, which meant that the sites of many old mineral workings could be built on, afforested or returned to agriculture.

During the fourth session, three papers were read to the conference on the need of land for urban and industrial development. Sir Herbert Manzoni, chairman of the Building Research Board (Department of Scientific and Industrial Research), said that production lines and mechanical handling had tended to increase the amount of space required by industry, and the majority of new factories were single-story. This trend might be reversed by developing vertical production lines and building upwards. Numerically, the population of Britain was very nearly housed, although housing is unevenly distributed; nevertheless, we already had nearly one house to three people. The real problem was the dreadful congestion of some of the urban areas. We were tending to forget the art of urban living, and in solving congestion problems we should not forget that some people like to live in towns. Current development plans would probably mean that a further half a million acres would be needed for urban development in addition to the two million acres at present occupied by housing, schools and industry. This was quite a small proportion of the total amount of land available.

Mr. P. A. Macrory, chairman of the Location of Industry Committee of the Federation of British Industries, produced three criticisms of the impact of land planning over the past three years. First, it was often far too difficult to find out exactly what the planning policy for any particular area was. Secondly, an industrialist who learns that he will be 'non-conforming' in five, ten or twenty years time often cannot discover when he will have to move, nor how much compensation he can expect. Lastly, planning control was carried down to quite unnecessary detail, and there tended to be a general negative attitude towards the industrial developer. These points all tended to get planning a bad name, but they could be remedied by more consultation and a more constructive attitude.

Prof. J. Sykes, of University College, Exeter, examined the effect planning has had on the location of industries in the past ten years. It appeared that it had so far been fairly successful in combating industrial congestion. One loophole was the fact that industrial premises vacated by non-conforming firms would be immediately filled by new firms. The local authority should supervise the change of use of premises and have the duty to offer alternatives to firms.

Summing up the conference as a whole, the chairman emphasized that this subject must be seen in relation to national and international economy. The increase in world population, and the industrialization of food-exporting countries, meant that if we wanted to import food we should only be able to do it by producing goods at a very high level of scientific and

industrial achievement. In deciding the best way to divide the very limited amount of land available so that it was used to the best advantage for the whole of Britain, it was essential to know exactly what one had to divide.

This brought the conference back to the point made by Sir George Pepler at the beginning of the conference, and which came up repeatedly in discussion, namely, the need for more accurate information about how land is actually being used in Great Britain—for, as Dr. Wibberly, of Wye College, pointed out at one point, even the figures of urban acreage are in dispute.

The conference therefore concluded by agreeing to forward the following resolution to the Council of the British Association: "That the British Association for the Advancement of Science represent to Her Majesty's Government the importance of arranging for the collection and publication of comprehensive statistics of the present use of all land in this country and to prepare an analysis on a national basis of the development plans now being submitted for approval in such a way that a balance sheet of land use may be drawn up. The Association submits that the collection of this factual information is a vital need in the present stage which town and country planning has reached in this country and in the formulation of national policies of land use". JOHN DAVY

SOCIETY FOR THE STUDY OF FERTILITY

ANNUAL CONFERENCE

THE Society for the Study of Fertility held its annual conference during June 23–24 in the Anatomy Department of the University of Birmingham. Prof. A. M. Dalcq discussed some of the processes of synthesis occurring during the early stages of embryological development in rodents, as revealed by cytochemical studies. In the first of two stages which can be differentiated, there is a step-wise production of deoxyribonucleic acid. In the second stage, heralded by the differentiation of the embryonic knot, synthesis leads to the formation of granules rich in ribonucleic acid, which afterwards gives rise to specific proteins and the formation of enzymes. The enzymes at first are polyvalent; but later different specific enzymes appear. Embryonic development will be described more and more in terms of biochemical differentiation; at present, of course, it is possible to demonstrate this only in terms of cytochemistry. R. A. Beatty described experiments with rabbits designed to test the Russian hypotheses that heterospermic insemination (where semen from two or more donors is mixed prior to insemination) leads to specially beneficial effects among the offspring in respect of litter size and fœtal weight. The results he has obtained give no support whatever to these views, and it is concluded that the litters derived from heterospermic insemination are in no way superior to those resulting from homospermic insemination.

W. R. M. Morton has studied the effects on the mating behaviour of rats caused by section of the olfactory tracts and removal of the olfactory bulbs. He concludes that complete removal of the olfactory pathways interferes with the total mating reaction but does not entirely prevent effective copulation. P. P. Scott and M. A. Lloyd-Jacob have made a study of reproduction in the domestic cat as maintained in an animal colony. It proved possible to follow the œstrous cycle by means of vaginal smears, and œstrus was found to occur at 12–14 days intervals, lasting 4–6 days. Typical œstrous behaviour was usually shown only in the presence of a tom cat, and the authors described a characteristic lateral flexion of the tail which was never observed except when œstrogens were present in significant amounts. Several consecutive matings during the period of œstrus seemed to be necessary in order to lead to conception, and the average duration of pregnancy was 65 days. A remarkable excess of males over females in the litters born was found, the ratio being 133 males per 100 females at birth.

Further studies were reported from the Anatomy Department of the University of Liverpool, under the direction of Prof. R. G. Harrison, on male reproductive physiology. E. W. MacMillan and R. G. Harrison demonstrated that the ductus epididymidis possesses an inherent peristaltic activity essential to sperm propulsion by following radiographically the passage of 50 per cent barium sulphate solution injected into the rete testis. Within four days of injection, the mass occupies a position at the junction of body and tail, and by seven days it has reached the tail loop. The vas deferens is entered on the thirteenth day, and the genital tract is completely emptied by the fourteenth day. The rate of progress is unaffected by ligation of the vasa efferentia or by ipsilateral orchidectomy. R. Harris and R. G. Harrison have investigated the effect of low temperature on the guinea pig testis. They found that little permanent damage resulted, provided the temperature within the testis did not fall below 0° C., and that freezing was more damaging than supercooling. Below that temperature occlusive spasm of the testicular artery occurred. Severe spermatogenic damage resulted from exposure of the testis to − 3° C. for one hour, but a temperature of − 10° C. was necessary to ensure an intratesticular temperature of − 4° C. when the scrotum was frozen. Severe spermatogenic destruction led to a 90 per cent fall in testicular volume.

T. D. Glover described the effects of scrotal insulation, as a means of raising the testicular temperature, on the semen of the ram. Five days elapsed before any changes in the semen appeared, and then an increased proportion of coiled tails was seen. Following this, separation of heads and tails was observed, and a marked fall in the sperm density took place about two weeks after the commencement of the scrotal insulation. Insulation for a period of only twenty-four hours led to a brief change in the semen about twenty days later, but, after a further four days, the normal semen picture was resumed.

M. W. H. Bishop discussed the inter-relationships of semen characteristics in the bull. Conception-rate was found to be most closely correlated with impedance change frequency and inversely with the percentage of dead sperms. The most significant conclusion, however, arising from his study was that a large amount of variation in fertility could not be related to any of the numerous semen characteristics examined. E. G. Bassett gave a review of investigations recently carried out at the Ruakura Animal Research Station in New Zealand on problems related to fertility in farm animals.

A number of papers on human fertility were given by workers at the Royal Free Hospital, London.

Mary Barton has found a high frequency of female infertility in couples where the husband was sterile and donor artificial insemination was contemplated. The high rate of failure of such insemination in women who, by the usual standards of investigation were regarded as fertile (and for whom, of course, apparently highly fertile semen was used), was also noticeable. Sara Field-Richards and M. Moore White described the use of local œstrogen therapy for uterine hypoplasia, and Phyllis Wade reported a pregnancy in a woman who had suffered from amenorrhœa following radiotherapy for ankylosing spondylitis.

G. I. M. Swyer reported a statistical assessment of post-coital test results which confirms the diagnostic, and to a lesser extent prognostic, value of the test. The not infrequent discrepancy between post-coital test results and semen examination means that the former cannot be regarded as a redundant step in infertility investigation. Clare Harvey discussed cytological events in the human testis, as revealed by biopsies in subfertile men, in relation to abnormalities in sperm morphology. She found that a high proportion of pear-shaped heads was correlated with subfertility and that these pear-headed spermatozoa developed as a result of abnormal maturation of spermatogonia. Claude Taylor reported a conception following the insemination of centrifuged urine passed after intercourse by a man who was suffering from retrograde vesicular ejaculation. Oral treatment with potassium citrate maintained an alkaline urine in which spermatozoal activity persisted. Vigorous spermatozoal activity was found, so long as the urine *p*H was close to 7, but when either too acid or too alkaline, the spermatozoa failed to survive.

Three films were shown: one was on social behaviour in rhesus monkeys, by M. R. A. Chance; another, by H. G. Hanley, demonstrated a simplified and apparently effective technique for the operation of epididymo-vasostomy; and the third, by Prof. Richard J. Blandau, was on reproduction in the rat.

INTERMETALLIC SEMICONDUCTORS

ALTHOUGH some of the earliest semiconductors of practical importance were chemical compounds, research interest in later years has been mainly in the elements germanium and silicon, partly due to the importance of transistor technology and partly because the problems of obtaining high purity and crystalline perfection appeared to be easier in a monatomic solid, and the theoretical interpretation more promising. However, with the extension of applications, new combinations of properties are desired, and it has been necessary to consider new materials—in particular, compounds, as there is little scope among the remaining elements. This trend was stimulated by the work of Welker in 1952 on compounds of the zinc-blende structure (isomorphous with germanium, but with alternate sites occupied by the respective elements). These were shown to have the high electron mobility characteristic of germanium and silicon which is essential for many applications. Still other types of compound may also have this property, so that the search has not been confined to zinc-blende types: generally, the group of compounds known as 'intermetallic' (that is, between elements having metallic properties, although the limits are not clearly defined) have shown the most interesting properties, and these are now being studied in a number of laboratories.

A study of compound semiconductors brings new problems of purification and crystal growing. The properties have then to be determined and interpreted in terms of theory, which may have to be extended or adapted in the process. Generalizations have to be attempted in order to guide further work. Finally, new applications of particular materials have to be considered. These points formed the theme of a symposium on intermetallic semiconductors which was held during April 26–27 at the Services Electronics Research Laboratory, Baldock, Herts, attended by more than a hundred and thirty visitors. The chairman for the first day was Prof. N. F. Mott (Cambridge), and for the second Prof. H. Welker (Siemens-Schuckertwerke, Erlangen, Germany). A total of nineteen papers was presented, mostly of a fundamental nature, with the emphasis on compounds of the zinc-blende type. In particular, the compound InSb, for which both the technology and theory are furthest advanced, received much attention. Arrangements have been made to publish the full papers in a special issue of the *Journal of Electronics*.

Three of the papers dealt with generalizations of a theoretical nature. Dr. F. Herman (R.C.A., Princeton), in a paper read by Dr. H. W. Leverenz, put forward a method for correlating the electronic band structure of zinc-blende type compounds with position in the periodic table of the elements concerned. In, for example, the isoelectronic sequence Ge (which may be regarded as the zinc-blende compound GeGe), GaAs, ZnSe, CuBr, the crystal potential is regarded as primarily that of germanium with a small perturbing potential due to the ionic contribution in the binding, the strength (s) of which increases in equal steps as we proceed along the sequence. For the regions of interest in momentum-space, the energy shifts are found to be quadratic in s. Measured values of the forbidden energy gap should show this same dependence, provided that no switch over occurs in the positions of the band edges in momentum-space. This latter possibility prevents outright prediction in the absence of supporting evidence, but the theory should be very useful in forming an early picture of the band structure in particular compounds of this type.

Similarly, C. H. L. Goodman (General Electric Co., Ltd., Wembley) offered a basis for the prediction of the electron mobility for a zinc-blende compound from a knowledge of the forbidden energy gap and the lattice spacing. He assumes that the covalent contribution to the binding energy and hence to the energy gap depends only on the interatomic distance (d) and is the same function of this as in the case of the Group IV elements. The excess of measured energy gap over that for a hypothetical Group IV element of the same spacing is regarded as an ionic contribution (E_{ion}). The quantity $(E_{\text{ion}}d^3)^{1/2}$ should be closely related to the bond dipole, which in turn should control the mobility, both through its influence on the effective mass, as discussed by Seraphin, and through its effect on the scattering of electrons by optical modes of lattice vibration. A plot of existing data on mobility against this parameter does give, in fact, a smooth curve, with a peak in the region of InSb, from which values for other compounds can be estimated with a fair amount of plausibility.

Still another general paper dealt with the problem of donor impurity-levels. Dr. G. Rickayzen (Services Electronics Research Laboratory, Baldock) outlined an attack on this problem in which he has examined quantum mechanically the validity of the usual hydrogen-atom model for a donor centre. He finds on certain assumptions—in particular, that the bound electron can be regarded as moving adiabatically through the lattice—that the model is justified to within an accuracy of 10 per cent, which is in rough agreement with the spread of activation energies found in practice. The accuracy should improve for structures in which the effective mass of conduction electrons is low.

Of the papers dealing specifically with InSb, the first two were concerned with photo effects. Dr. T. S. Moss (Royal Aircraft Establishment, Farnborough) gave the theory of photoconductive and photovoltaic behaviour for the case of a material like InSb which is in the intrinsic range of conduction, which has a high ratio of electron to hole mobility, and in which the rate of recombination of holes and electrons at the surfaces can be high. From photovoltaic measurements, a value of the carrier life-time can be deduced, typical values obtained for InSb being of the order of 1 μsec. Photoconductive data lead similarly to values of the surface recombination-rate; this is very dependent on surface processing, but values in the region 5×10^4–6×10^5 cm./sec. were quoted (compare with ~ 100 cm./sec. in germanium). The second paper, by C. Hilsum, Dr. D. J. Oliver and Dr. G. Rickayzen (Services Electronics Research Laboratory, Baldock), dealt similarly with the photoelectromagnetic (Kikoin) effect. From this also the surface recombination velocity can be derived, the values reported agreeing with those of Dr. Moss. The method also measures life-time, for which values in the range 0·07–0·3 μsec. have been obtained.

Carrier life-time in InSb was the subject of two further papers. The first by I. M. Mackintosh (University of Nottingham) and J. W. Allen (Ericsson Telephones, Ltd., Nottingham) discussed the photon-radiative recombination process, which appears to be the dominant mechanism in this material, since it leads to the correct order of magnitude for the life-time. They showed that a theory of radiative recombination in which the probability of a transition between two levels is independent of the energies, at least over a small range, gives the correct frequency-dependence. They suggested also that InSb should be an efficient infra-red emitter. In the second paper, Drs. D. G. Avery and D. P. Jenkins (Radar Research Establishment, Malvern) described an experimental determination of the life-time by the light-spot method. Values of 0·3 μsec. were obtained at room temperature for InSb of high purity. The life-time rises with decreasing temperature, as expected from a photon-radiative process, but falls anomalously below 200° K.

V. Roberts and J. E. Quarrington (Radar Research Establishment, Malvern) described work on an accurate determination of the optical absorption in InSb over a range of temperature down to 4° K., the aim of which was to interpret in detail the electronic transition processes taking place at wave-lengths close to the absorption edge. Comparison of the results with published theoretical predictions suggests that 'indirect' transitions—that is, those in which momentum is conserved only by simultaneous emission or absorption of a phonon—are important at low levels of absorption. It is usually assumed in semiconductor work that the energy (E) of conduction electrons varies quadratically with their momentum (k); Dr. R. Barrie and J. T. Edmond (Services Electronics Research Laboratory, Baldock) showed by an analysis of thermoelectric, Hall effect and optical data that, for InSb with concentrations of electrons of 10^{18}/c.c. or above, this approximation is not a good one. A better overall fit up to 10^{19}/c.c. is obtained with a law of the form $E = \alpha k^2 (1 - \beta k^2)$.

Dr. B. V. Rollin and A. D. Petford (Clarendon Laboratory, Oxford) reported results of conductivity and Hall effect measurements down to a temperature of 1·5° K. on single crystals of InSb with total impurity contents in the range 10^{16}–10^{17}/c.c. In n-type material the activation energy for conduction appears to be zero. This, they suggested, is due to overlap of bound orbitals, which will occur at lower impurity concentration in InSb, than, for example, in germanium, because of the lower effective mass. For p-type material an activation energy of 0·005 eV. was obtained. The carrier mobility fell off at very low temperatures, suggesting that conduction was now taking place in an impurity band. In p-type material at low temperatures the anomaly was found of a negative magneto-resistance coefficient. Magneto-resistance also was the subject of a paper by Dr. R. Mansfield (Bedford College, London), who had studied the behaviour of highly degenerate polycrystalline specimens of InSb. The magneto-resistance coefficient did not fall off with decreasing temperature in the manner expected from simple theory, but he felt that this would need confirmation on single crystals, since it may have its explanation in inhomogeneities associated with grain boundaries.

In a semiconductor, such as InSb, in which the ratio of effective masses of holes and electrons is appreciably different from unity, Fermi–Dirac degeneracy can occur in the intrinsic range. It is not then possible to calculate the electron and hole concentrations analytically for a known temperature and energy gap. Prof. G. Busch (Physikalisches Institut der Eidgenössen Technischen Hochschule, Zurich) discussed a simple method of doing this graphically and illustrated a slide rule based on the same principle.

A further group of papers was concerned with other compounds. Prof. H. Welker described recent work on Group III–V compounds. The energy gap in GaAs is now believed to be 1·4 eV. and the ratio of electron to hole mobility to be 10, the former being estimated as 6,800 cm.²/V. sec. at room temperature in the pure substance. Resistivities as high as 100 ohm cm. have been obtained. For InP, the corresponding figures are 1·3 eV. and 3,300 cm.²/V. sec. with resistivities up to 10 ohm cm. The compound GaP is interesting in that it is transparent and of a light-golden colour. The energy gap is 2·2 eV. By mixing GaAs and GaP it is possible to vary the energy gap continuously between the two extremes.

Another III–V compound, InAs, was the subject of a paper by Drs. R. M. Talley and F. Stern (U.S. Naval Ordnance Laboratory, Washington, D.C.). This material shows properties similar to InSb, including a shift of absorption edge with increasing concentration of donor impurity. Assuming that the impurities are distributed in an ordered manner, an overlap of bound orbitals will lead to an impurity

band the width of which increases with concentration of impurity. The mid-point of this band will overlap the conduction band, they estimate, at a concentration of 10^{16} atoms/c.c. Above this concentration the material will continue to be conducting down to zero temperature, analogously to the results reported by Rollin and Petford for InSb. The lowest unfilled level available for optical transitions will increase with rising donor impurity content; on the other hand, the addition of electron acceptor impurities should empty the upper levels and therefore extend the limit of optical transitions to longer wave-lengths. This they have observed experimentally.

The compound CdTe was dealt with in a paper by Dr. F. A. Kröger and D. de Nobel (Philips Research Laboratories, Eindhoven) in which they described the preparation and properties of single crystals. Both *n*- and *p*-type crystals can be obtained by adjusting the stoichiometric balance, which can be done by heating the crystal in a suitable pressure of cadmium vapour. Thermoelectric measurements gave values for the effective masses of electrons and holes of 0·37 and 0·14 times the free mass, respectively. The corresponding mobilities were 600 and 50 cm.²/V. sec. Estimates of the energy gap gave two different possible results: the value could be either 0·37 or 0·2 eV. W. S. Lawson (Radar Research Establishment, Malvern) similarly dealt with the compound Mg_2Sn, of which he has grown crystals of high purity. The value of the energy gap is 0·34 eV. from measurements of Hall constant, and the same result can be derived from variation of the conductivity with temperature if plausible assumptions are made about the dependence of mobility on temperature. The mobilities at room temperature are 220 for electrons and 260 cm.²/V. sec. for holes.

Drs. J. van den Boomgaard, F. A. Kröger and H. J. Vink (Philips Research Laboratories, Eindhoven) gave a short paper on a technique of zone-refining a compound, such as PbS, in which one of the components, here sulphur, is volatile. The compound is sealed in a silica tube, one end of which is extended and connected to a sealed reservoir of the volatile compound. During the refining the auxiliary reservoir is kept at a temperature sufficient to give the desired vapour pressure of the volatile constituent, the remainder of the tube being kept at a rather higher temperature.

Finally, there were two papers dealing with applications. H. J. Goldsmid (General Electric Co., Ltd., Wembley) discussed the factors controlling the efficiency of a thermoelectric generator. The Fermi level (chemical potential) should lie near the edge of the appropriate band, and the mobility (μ) should be large, but not due to the occurrence of a small effective mass (m^*); the controlling factor is $\mu(m^*)^{3/2}$, which should be large. The lattice component of thermal conductivity should be small. These requirements are most likely to be met when the mean atomic weight is large. For example, bismuth telluride (mean atomic weight 160) is particularly efficient. Using a junction of *n*- and *p*-type material, an appreciable Peltier cooling has been obtained (40 deg. C. refrigeration). The abnormally high electron mobility of InSb has led to a number of new applications, discussed in a paper by I. M. Ross and Dr. E. W. Saker (Services Electronics Research Laboratory, Baldock). The power available from the Hall effect is proportional to the square of the mobility, which gives InSb, with its electron mobility of 60,000 cm.²/V. sec., a factor of ~ 300 improvement over germanium. Applications based on this feature include sensitive magnetometers, an electric compass, and a new type of power amplifier in which the input signal modulates the magnetic field in a thin crystal of the material. A new transducer principle is also possible in which the displacement to be observed causes the crystal to move in a steeply varying magnetic field. Using InSb as a resistance 'gyrator', a backward attenuation of ~ 80 db. can be obtained for a forward loss of only 7·5 db. I. M. Ross

LIBERAL VALUES IN FURTHER EDUCATION AND TRAINING

UNDER the title "Liberal Education in a Technical Age", the National Institute of Adult Education has published the report of a survey of the relationship of vocational and non-vocational further education and training conducted by a Committee set up early in 1953 by the Institute jointly with the Associations of Technical Institutions and of Principals of Technical Institutions, with Sir Robert Wood as chairman and Dr. P. F. R. Venables as vice-chairman. Regarding a liberal education as one which includes a training in the use of language, in the handling of ideas, in recognizing relationships, and in establishing values as touchstones for questions of taste and morals, the Committee concerned itself with the fundamental questions of the extent to which these values are affected if a study is undertaken from motives connected with personal advancement, and the extent to which they are excluded from certain studies because of their subject-matter. Attention was concentrated on the work of the technical institutions and colleges of art, correspondence courses, adult education and residential colleges, and on the role of the professional and examining bodies. Following three chapters dealing with the background of the inquiry, which include statistics relating to institutions and students, there are chapters on each of these aspects, as well as one on teachers and students in technical institutions.

Broadly, the Committee addressed itself to three questions: the extent to which technical institutions recognize any responsibility for giving their students something more than vocational instruction; if such responsibility is recognized, whether the conditions under which further education is carried on permit of anything beyond the essential technical instruction; and whether, to maintain a due balance between vocational and general education, we should look to changes in the curricula of technical institutions, or to the phasing of the whole educational process. The Committee believes that at no period in the educational process should the values commonly associated with a general education be dropped because of the intense pressure of vocational preparation, and it declined to support any suggestion that students entering technical institutions can properly embark upon a period of narrow and specialist education to the neglect of other studies. This more generous view of vocational education, it found, is held by many principals and teachers in technical institutions in spite of the gap existing between what is regarded as desirable and what is,

in practice, achieved. It emphasizes that the problem can only be resolved by the pressure of public opinion and, in particular, when industry, commerce and public administration at all levels of responsibility, from higher management to supervision, share the serious concern voiced by a minority, to the extent of a readiness to extend day-time release and insist on including non-vocational as well as vocational studies.

The sharpest criticism made by the Committee is of some of the professional and examining bodies, the papers and syllabuses of which are framed to encourage the memorizing of facts rather than the discussion of underlying principles. This practice is largely responsible for the narrowness of certain technical studies, and the Committee believes that these bodies should be invited to re-assess the purpose and nature of their examinations. The Committee also comments on the unsatisfactory physical environment in which the work of technical institutions is often performed. It welcomes the recent relaxation of the utilitarian attitude of the Ministry of Education towards vocational education and hopes that local education authorities and governing bodies will now press forward with the improvement of physical conditions, including the equipment and maintenance of libraries, an increased supply of technical and non-technical books and periodicals, and the provision of adequate refectories, recreation and common rooms. The Committee believes that all education must aim at increasing human sympathy and understanding, sharpening æsthetic appreciation and giving a better command of language, and to this end it recommends that human relations in industry and commerce should be more widely studied and the æsthetic appreciation of design appropriately emphasized. It further recommends that, in technical and professional examinations at all levels, some regard should be had to the qualities derived from liberal studies, and directs attention to the value of short periods of residential education and of foreign travel. It suggests that the links between technical institutions and the responsible bodies in adult education could be strengthened with advantage to both and that the experiments being made in the university world on the reconciliation of vocational and liberal education could be profitably studied in relevance to other forms of higher education.

INTAKE OF NUTRIENTS BY SUGAR-BEET

A STUDY of the interactions of nitrogen, phosphorus and potassium, supplied in leaf sprays or as fertilizer added to the soil, has been reported on by G. N. Thorne (*J. Exp. Bot.*, **6**, 16, 20; 1955). Among findings of special interest are the following.

When sugar-beet plants grown in pots were sprayed daily with nutrient solutions supplying nitrogen, phosphorus and potassium separately or in all combinations, with precautions to prevent spray falling on the soil in which the plants were grown, all three nutrients were absorbed through the leaves. In one experiment nitrogen and potassium, and in another only nitrogen, caused increases in plant dry weight and leaf-area. Swedes absorbed phosphorus from leaf sprays and from fertilizer applied to the soil, but only the fertilizer caused an increase in dry weight.

Absorption of any of the nutrients tested from a spray containing more than one nutrient was unaffected by the presence of others in the spray; but spraying with nitrogen-containing solutions increased the absorption of phosphorus and potassium from the soil, and potassium in sprays increased the uptake of phosphorus from the soil. Nitrogenous fertilizer applied to the soil increased the leaf-area of sugar-beet plants, and hence it also increased the amounts of nitrogen, phosphorus and potassium deposited on the leaves when they were sprayed with solutions of these nutrients, and the amounts absorbed from the spray into the plants. Phosphatic fertilizer had no effect on uptake from leaf sprays. Potassic fertilizer did not affect leaf-area or the estimated volume of spray solution retained on the leaves; but it appeared to reduce uptake of potassium from the spray. Dry weight per plant was increased by all three nutrients in fertilizer, and sugar yield of the roots was increased by nitrogen and potassium in fertilizer, and by nitrogen in spray. Application of a nutrient in leaf spray reduced the responses in dry weight and sugar yield to the same nutrient applied in fertilizer to the soil.

JUTE PRODUCTION AND RESEARCH

READERS interested in the problems of jute production in India will find a comprehensive account of relevant matters in the annual report of the Indian Central Jute Committee (for 1953–54, pp. 1–300; Calcutta) and in the annual report of the Jute Agricultural Research Institute (1953–54, pp. 1–145; 1955, Calcutta).

The primary object of this central authority is to deal with research on all aspects of jute from field to factory. The reports accordingly have sections devoted to the relevant agricultural, technological and economic aspects. At the Jute Agricultural Research Institute the programme includes jute breeding and cytogenetics, special problems of anatomy, the agronomy of jute and of crops yielding substitute fibres, and related physiological, microbiological and entomological problems. On the technological side, in addition to the normal testing, development and processing work, more fundamental researches on chemical and physical aspects have also been undertaken.

In investigations of the chemistry of the hemicelluloses of jute and other fibres it has been found that these are generally similar. Further evidence has been obtained supporting a hypothesis put forward earlier of a chemical combination between the carboxyl group of the hemicellulose and the hydroxyl group of the lignin in jute. On the physical side, the torsional rigidity of jute, ramie and sisal has been measured. It has been ascertained that heavier filaments have generally lower values for rigidity modulus and that porosity appears to be related inversely to rigidity. The elastic properties of jute filaments from plants at different stages of growth, and the effects of chemical and physical treatments on the hardness modulus of jute fibre, have been investigated. Some progress in X-ray investigations of jute fibre is also reported: here the principal aim was to ascertain the size of the micelles in fibres of different quality ratios.

THE LAMELLIBRANCH MUSCLE

Contractile Mechanism

THE tetanic nature of muscle activity is no longer disputed except in the case of lamellibranch smooth muscle, which is supposed to maintain tension by a unique 'catch' mechanism. This postulates that viscous components within the muscle fibre should 'catch' the contractile elements and hold them at constant length in the manner of a ratchet[1,2]. I have found previously[3,4] that maintenance of tension in *intact* smooth lamellibranch adductors is accompanied by continuous electrical activity due to discharges from muscle fibres. From this it could be argued that tonus in these *intact* muscles is due to a shifting pattern of tetanic stimuli controlled by the nervous system, thus bringing it into line with tonus in other muscles and making unnecessary the hypothesis of a 'catch' mechanism.

There remained one major difficulty: if the nerves leading to the posterior adductor of *Mytilus* are cut, the muscle continues to maintain tension although it seems to be electrically 'silent'[3]. By using an improved recording technique I have now shown that, in fact, spontaneous electrical activity always accompanies maintenance of tension in such (externally) denervated lamellibranch muscles—a finding which strongly suggests that, even in this case, the mechanism is tetanic.

The improvement in technique mentioned above was a modification of the recording conditions. Instead of using fine electrodes recording from a very localized region[3], larger electrodes were employed in order to detect activity in a greater number of muscle units. Such electrodes consisted of 3 cm. length of 40 s.w.g. platinum wire (coated with platinum black), and they were placed around isolated muscles of eviscerated animals in air. After amplification the muscle potentials were recorded with an ink-writing oscillograph.

As recorded, the largest action potentials in muscles denervated as described above measure about 50 μV.; but in many preparations the spikes were barely visible above the noise-level of the amplifier. However, by using completely fresh animals, spontaneous action potentials have been recorded from the following (externally) denervated muscles: the wholly smooth adductors of *Mytilus*, the smooth and spirally striated parts of the adductors of *Anodonta* and *Modiolus*, the smooth part of the *Pecten* adductor, and from the smooth retractors of these animals.

In an earlier paper[3] I have shown that the pattern of electrical activity during tonus in the intact *Mytilus* adductor consists of persistent asynchronous discharges of greatly varying size, indicating continuous local activation; and of intermittent volleys of muscle potentials, evidently due to discharges from a much greater number of muscle units (Fig. 1*a*). Now in the case of all the lamellibranch muscles examined so far, there is generally less electrical activity in (externally) denervated than in intact muscles. Apart from this—in smooth adductors—the only difference is the absence of the volley response in all but the *Mytilus* muscle. Here volleys of a relatively shorter duration have been observed in many (but not in all) denervated preparations (cf. Fig. 1*b*). Spontaneous asynchronous discharges are also present in denervated spirally striated adductors, though their amplitude is considerably smaller than that of the discharges in the smooth muscle (Fig. 1*c*). Volleys have only been observed in very few preparations of denervated spirally striated adductors (cf. Fig. 1*c*). So far, no electrical activity has been detected in the denervated transversely striated *Pecten* adductor.

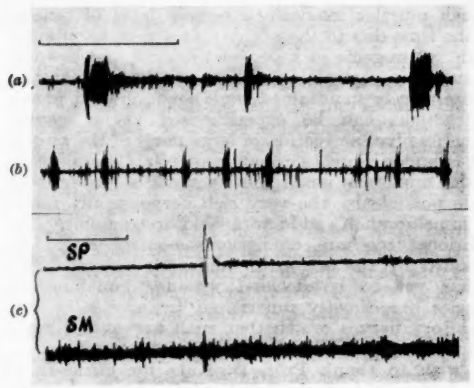

Fig. 1. The records read from left to right; time marker indicates 1 min.: *a*, *Mytilus*, intact posterior adductor. Spontaneous electrical activity during tonic contraction; *b*, same, after (external) denervation in a preparation which showed volley responses; *c*, *Modiolus* (externally) denervated posterior adductor. Spontaneous electrical activity in the spirally striated (*SP*) and smooth (*SM*) parts during tonic contraction. (Note: in this preparation the spirally striated muscle showed sporadic volley responses)

The experimental evidence presented here leaves little doubt about the tetanic nature of tonus in (externally) denervated lamellibranch muscles. But how is the tetanus maintained? There are certain difficulties in the way of a myogenic explanation: only in syncytial muscle systems, like the vertebrate heart, has the self-excitatory capacity of the muscle fibres been conclusively demonstrated—and here the action potential is of the 'unitary' type. In contrast, the electrogram of lamellibranch muscle shows responses of such irregular nature and variable size that a total syncytium seems out of the question. The electrical picture is much more in keeping with the activity of numerous independent units. Of course, the units themselves could be syncytial, thus allowing for localized activity. For this, however, there is as yet no histological evidence, and in view of the very small size of the muscle fibres (2–10μ diameter) the problem is not readily tackled from the structural point of view. Considerations of size also make it difficult to look for syncytial continuities between muscle fibres with intracellular electrodes.

The recent finding of nerve-cell bodies in a variety of lamellibranch adductors and retractors[5] appears to favour a nervous origin of the spontaneous muscle-action potentials in preparations where the nerves leading to the muscle have been cut. If this be the case, then (to give both phasic and tonic responses) either the muscle fibres themselves would have to be doubly innervated or the peripheral neurones would have to be in synaptic relation with two types of motor nerve. Experiments designed to block selectively the excitatory action of possible peripheral nerve elements have so far not given conclusive results. Therefore, the question whether tonic activity in lamellibranch muscles is neurogenic or myogenic remains open.

Considering the evidence at present available, it appears that smooth and spirally striated lamelli-

branch muscles maintain a certain level of tension all the time due to the activity of a peripheral automatic (neurogenic or myogenic) system which works by successive activation of limited areas. Upon this spontaneously maintained tonic level, graded phasic contractions can be superimposed via a system which involves activation of large parts of the muscle and is under central nervous control[3]. Co-ordination of the numerous small muscle units is presumably made possible by the very rich nerve supply found in lamellibranch adductors and retractors[5]. An additional measure of nervous control might be provided by the action of inhibitory nerves[3]. But it has yet to be decided whether lamellibranch muscles are directly innervated by excitatory and inhibitory nerves or whether such nerves act via a peripheral ganglionic plexus.

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Innervation

Only two authors claim to have shown the minute innervation of lamellibranch muscle[1,2]. In 1888 Galeazzi[1] demonstrated the presence of an extremely rich intramuscular nerve plexus in the *Mytilus* adductor; but his work has hitherto been overlooked. He used the well-known formic acid–gold chloride technique to show how large nerve bundles divided and subdivided to form branches which for the most part ran parallel to the muscle fibres. From these nerves arose numerous finer branches, some of which ran towards muscle fibres, while others anastomosed freely to form a complex network. In addition to nerves, Galeazzi also reported the existence of a large number of nerve-cell bodies.

Bruch[2], using a Golgi technique, has reported the presence of motor end-plates in the spirally striated fibres of *Anodonta*. He maintained that these structures were essentially similar to those found in vertebrate skeletal muscle and differed from them mainly in being orientated at right angles to the long axes of the fibres. He was unable to obtain any nerve staining in the smooth part of the same muscle. Neither he nor a number of other workers[2–5] has made any mention of the presence of nerve-cell bodies.

In an attempt to confirm the above observations, a very large number of metallic impregnation and methylene blue techniques was tested. With the Ranvier gold chloride method it proved possible to demonstrate fine nerves, ending in bulbs, in the radial pallial muscles of *Pecten* and *Chlamys* and in the siphonal retractor muscles of *Mya arenaria*; but the results were never really satisfactory. Methylene blue was found to be excellent for tracing the course of the large nerves, but useless for showing details of innervation. With the other methods, no nerve elements could be stained. In view of the probable

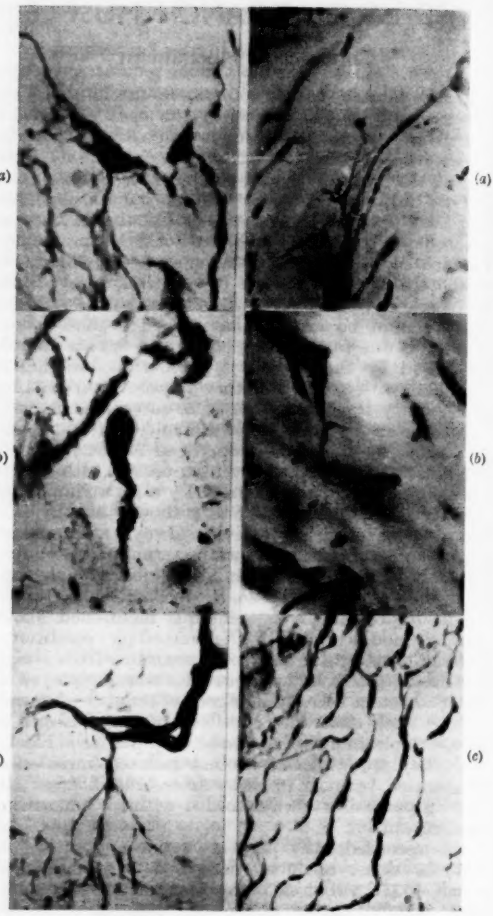

Fig. 2 Fig. 3

Fig. 2. Stained by the Koelle method (× 225). *a*, Multipolar nerve-cell bodies from the anterior byssal retractor muscle of *Mytilus*; *b*, unipolar nerve-cell body from the posterior adductor of *Mytilus*; *c*, nerve trunk branching to join nerve plexus in the posterior adductor of *Mytilus*

Fig. 3. Stained by the Koelle method. *a*, Nerve endings arising from finest branches of nerve plexus in the anterior byssal retractor of *Mytilus* (× 325); *b*, nerve ending arising from nerve trunk in the posterior adductor of *Mytilus* (× 300); *c*, nerve plexus from the smooth part of the posterior *Anodonta* adductor (× 375)

cholinergic nature of the lamellibranch neuromuscular system[4], histochemical methods for localizing cholinesterase were therefore tried.

With the myristoylcholine techniques[7], nerve-cell bodies can be seen in all the lamellibranch muscles so far examined; but the precipitate is too coarse to show the finer nerves. On the other hand, the Koelle method[8] gives excellent staining and reveals a nerve plexus corresponding closely to that described by Galeazzi (Fig. 2 *a*, *b* and *c*; and Fig. 3 *c*). This intrinsic nervous system is present not only in smooth adductors and retractors, but also in the spirally striated adductors. In addition, it is possible to demonstrate nerve endings with the Koelle method; but no structures like the 'motor end-plates' figured by Bruch[2] have yet been seen. Our work is still in progress and at present it is only possible to state that endings which arise from the larger nerves,

as well as from the finest branches of the plexus itself, appear to terminate in bulbs (Fig. 3 *a* and *b*).

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AZETIDINE-2-CARBOXYLIC ACID : A NEW CONSTITUENT OF PLANTS

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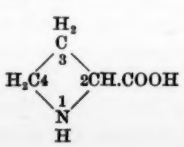
In recent years several new amino- and imino-acids have been encountered in plants and, in many cases, the new nitrogenous substances have constituted a large percentage of the total soluble plant nitrogen[1]. A further example has been found in *Convallaria majalis* L. (lily-of-the-valley). Two-directional paper chromatograms (phenol : butanol–acetic acid) of leaf extracts, prepared using 70 per cent ethanol, showed that the main spot was one reacting brown with ninhydrin and represented a substance not previously reported as present in plants. This new substance (hereafter termed ***Z***) had an R_F value of 0·80–0·84 in phenol-ammonia, and moved at a rate similar to threonine and glutamic acid in *n*-butanol-acetic acid.

By ion-exchange column chromatography ('Zeocarb' 215—0·15 *N* ammonia displacement) and subsequent paper chromatography on washed Whatman No. 3 filter paper, 250 mgm. of ***Z*** were isolated from 1·8 kgm. of fresh, mature *Convallaria* leaves. Three recrystallizations from 95 per cent methanol yielded ***Z*** as a white solid, with an elementary analysis of C, 47·6; H, 6·82; N, 13·4; O (by difference), 32·2. This approximated to the analysis calculated for $(C_4H_7NO_2)_n$, namely, C, 47·53; H, 6·93; N, 13·86; O, 31·68. Barger's method showed that the molecular weight of ***Z*** was approximately 100, indicating that *n* is 1 in the provisional formula.

Assuming the formula $C_4H_7NO_2$ and that the molecule contains a —COOH group and either an amino- or imino-group, the only type of open-chain compounds compatible with the formula would contain either a C=C or a C=N. ***Z***, however, did not show any of the typical reactions associated with such structures, being unaffected by catalytic hydrogenation or ozonolysis. Alternatively, cyclic structures could satisfy the formula. One of the possibilities, azetidine-2-carboxylic acid :

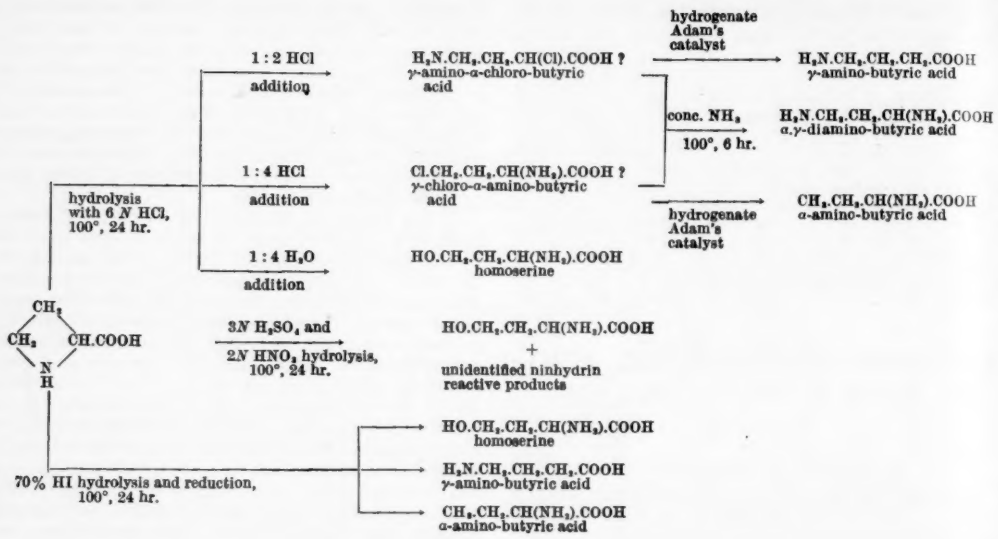


might be expected to possess all the properties determined for ***Z***. Although no account of this cyclic imino-acid appears in the literature, the parent compound, azetidine, is known, and is stable under conditions of alkaline hydrolysis, but is unstable to acid hydrolysis. Hydrolysis of azetidine with aqueous hydrochloric acid yields two products, α-amino-γ-hydroxy-propane, and α-amino-γ-chloro-propane, by ring fissure and simultaneous addition of either water or hydrochloric acid[2].

Z was stable to alkaline hydrolysis (5 *N* barium hydroxide solution for 24 hr. at 100°), but was completely decomposed by 6 *N* hydrochloric acid at 100° for 24 hr., yielding three ninhydrin-reactive products. The major product was always inseparable from homoserine on paper chromatograms, irrespective of the five solvents used ; the other two products first appeared as yellow spots after ninhydrin development, later changing colour through brown to a bluish-purple. These two compounds were first thought to be unsaturated since they could be converted by catalytic hydrogenation to substances inseparable from γ-amino- and α-amino-butyric acids on chromatograms ; but evidence now exists suggesting that they were α-chloro-γ-amino- and γ-chloro-α-amino-butyric acids respectively. Treatment of both compounds with concentrated ammonia solutions yielded α.γ-diamino-butyric acid. By comparison with the known mode of hydrochloric acid fissure of azetidine, the primary products of hydrochloric acid hydrolysis of ***Z*** are those that would be expected to arise from azetidine-2-carboxylic acid by addition of water or hydrochloric acid after splitting of the ring in either the 1 : 2 or 1 : 4 positions. The fourth possible product, α-hydroxy-γ-amino-butyric acid, has not been recognized. Extra support is available in that the nature of the products of acid hydrolysis vary with the acid used. Homoserine, as would be expected, was formed when either 3 *N* sulphuric acid, 2 *N* nitric acid or 70 per cent hydriodic acid replaced hydrochloric acid, but the additional products were characteristic of the acid used. Since hydrogen iodide is a strong reducing agent, α- and γ-amino-butyric acids appeared, together with homoserine, as direct products of ring fissure. The suggested transformations following acid hydrolysis of ***Z*** are outlined in the accompanying scheme (p. 348).

Z, like proline, gave an intense blue colour with sodium nitroprusside in 10 per cent acetaldehyde solution in the presence of sodium carbonate[3]. This test is recorded as specific for secondary amines, and, under the test conditions used, was not given by a number of α-amino-acids tested simultaneously.

The identity of ***Z*** as azetidine-2-carboxylic acid has been confirmed by comparison with synthetic material. This was prepared by two methods. In the first method γ-amino-butyric acid was brominated to α-bromo-γ-amino-butyric acid, which was then refluxed for 10 min. with 0·5 *N* barium hydroxide solution to remove hydrogen bromide and effect ring closure. The alternative synthesis was based on that published for proline[4]. *l*-Diamino-butyric acid monohydrochloride, kindly supplied by Wellcome Research Laboratories, Beckenham, was first converted to α-chloro-γ-amino-butyric acid, and ring closure again effected using barium hydroxide to remove hydrogen chloride. The product of the first synthesis would be the *dl*-form of azetidine-2-carboxylic acid, whereas, by comparison with the proline synthesis, optical activity could be retained with inversion of configura-



tion in the second method of preparation. The samples of synthetic azetidine-2-carboxylic acid showed the same ninhydrin colour responses as *Z*, and were inseparable from it on phenol, butanol–acetic acid and collidine–lutidine chromatograms. The synthetic compounds were also cleaved on acid hydrolysis in identical ways to *Z*. Finally, the infra-red absorption spectrum of *Z* was identical with that of the synthetic material prepared from *l*-diamino-butyric acid (Fig. 1).

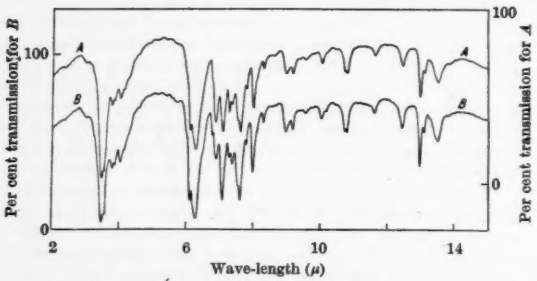
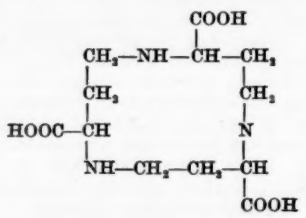


Fig. 1. Infra-red absorption spectra of nujol mulls of azetidine-2-carboxylic acid. (*A*) isolated sample, (*B*) sample synthesized from *l*-diamino-butyric acid. Absorption peaks at wave-lengths of 3·48, 3·53, 6·86 and 7·27 μ are largely attributable to the nujol

This finding of azetidine-2-carboxylic acid has extended the types of cyclic nitrogen compounds known to occur in plants, for simple four-membered ring systems based on azetidine have not previously been recorded. The existence in plants of this lower analogue of proline follows closely upon the recent discovery in plants of the higher analogue of proline, pipecolic acid.

The latter part of this work has been carried out in the laboratories of Prof. F. C. Steward, whose ready co-operation is gratefully acknowledged, during the tenure of a Rockefeller Foundation Fellowship. A fuller account of the investigation will be published elsewhere at a later date. [May 23

Note (June 17). Since this manuscript was prepared, an article by Prof. A. I. Virtanen and P. Linko has been published (*Acta Chem. Scand.*, **9**, 551; 1955), in which the isolation of a new nitrogenous compound from *Polygonatum officinale* was described. This compound (called I), which was also stated to occur in *Convallaria majalis*, is almost certainly the same as the substance *Z* described above. All the experimental data cited for I by Virtanen, with the exception of a molecular weight determination of 303, support the idea that I is in fact azetidine-2-carboxylic acid. Virtanen, however, concluded that I had the structure:



although no comparison with synthetic material was made. It would appear that this structure was dictated largely by the results of elementary analysis and molecular weight determinations.

Virtanen also described a compound (called II), which arose after hydrochloric acid hydrolysis of I, and he has ascribed a complex, unorthodox formula to this compound without supporting evidence. Compound II (stated to have an elementary analysis of $C_4H_7O_2N.HCl$) would seem to be more simply explained as a chloraminobutyric acid; II appears, in fact, to have the same chromatographic properties as the α-chloro-γ-amino-butyric acid described above, which gave γ-amino-butyric acid on reduction.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Instability of the Earth's Axis

In connexion with the theory of the instability of the earth's axis of rotation[1], it may be worth pointing out that, besides the evidence from fossil magnetism, it is possible that independent biological confirmation could be found of the occurrence of major latitude changes in the past history of the earth.

However the climate may have changed in the past, it is certain that the seasonal variation in length of day at any particular latitude must always have been the same; however warm the arctic winter may have been, it was always dark. Since photosynthesis is possible only in daylight, there must always have been a check to plant growth at high latitudes during the winter, whatever the temperature, and this will have left its mark in the form of annual growth rings in trees and other perennial plants. If plant fossils showing continuous growth without well-defined annual rings or other signs of a winter check could be found at the present time at higher latitudes, that would be good evidence of past latitude changes, for continuous growth without an annual winter check can never have been possible far outside tropical latitudes.

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[1] Gold, T., *Nature*, **175**, 526 (1955).

The possibility that changes have occurred during the past in the position of the earth's axis of rotation, relative to present surface features, is of great interest to all students of fossil plants. It has long been clear that the geological evidence of former vegetation shows that the lands around the Arctic Sea bore an ample covering of plants during a long period, probably from Devonian to Tertiary times. This vegetation included many large trees and was very different from the scanty flora of those regions living to-day. From other areas, such as South Africa, India and Australia, there is evidence of glacial conditions associated with relatively small flora.

Hitherto, almost all palæobotanists of the past twenty years have accepted the hypothesis of continental drift as being the only possible explanation of all the observed facts, in spite of the objections frequently raised to this theory. The new views summarized by Mr. T. Gold[1] will stimulate a re-examination of the palæobotanical evidence.

The use of fossil plants as tests of past climates has been under consideration for many years by many investigators, especially by Seward. The interpretation of the evidence is by no means easy, since the factors of temperature, rainfall, length of day and intensity of light are involved. The significance of growth rings in the stems of woody plants found in a petrified condition has been discussed by Gothan, Antevs and others; but there is a great lack of information about the stems of coniferous and other plants from the older rocks of high latitudes. Well-marked growth rings were present in trees of Mesozoic age from the arctic regions; but we should like to know whether they also occurred in trees of the same area during the Upper Devonian and Carboniferous periods. At this time the gymnospermous trees from Europe and North America showed little or no signs of a seasonal cessation of growth, whereas those from South Africa, India and Australia have very conspicuous growth rings. A specimen of petrified wood from the Antarctic Continent was described by Seward, in the report of the Scott expedition[2], as showing annual rings; but these were much less conspicuous than those in somewhat similar wood from South Africa.

There can be little doubt that the climatic changes, of which both rocks and fossils provide evidence, were of great importance in relation to the evolution of plants, and consequently to the past history of terrestrial animals. If geophysical research can establish how these changes came about, an important contribution to biology will be made.

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[1] Gold, T., *Nature*, **175**, 526 (1955).
[2] *British Antarctic (Terra Nova) Expedition*, 1910, 1, 17 (1914).

Reactions of Herring Larvæ to Light: a Mechanism of Vertical Migration

During the course of studies on the reactions of fish to light the opportunity arose for observing the behaviour of herring larvæ, *Clupea harengus* (Linn.). Initial observations were made on larvæ in shallow dishes illuminated from below by diffuse light. Each larva was dark-adapted and then observed for fifteen minutes at different light intensities, the total time spent moving in this period being recorded as a measure of its activity. The larvæ exhibited a positive photo-orthokinesis[1], their activity being proportional to the light intensity between two limits. The lower threshold for the kinesis was about 20 metre-candles, the larvæ being active for 20 per cent of the time below this intensity (down to at least 0·3 m.c.). At higher intensities, activity increased to a maximum at 4,000 m.c. when larvæ were active for 35 per cent of the total time; still higher intensities (up to 65,000 m.c.) did not increase activity further. When a light was shone at the side of the dish, larvæ swam directly towards it, showing a positive phototaxis.

Later experiments were carried out in a tall glass cylinder illuminated by diffuse light from above. Inactive larvæ sank head first weighted by their yolk-sacs; active larvæ swam directly upwards 'standing on their tails' or maintained their mid-water level, swimming horizontally. Very little swimming was observed at inclinations between these planes in larvæ up to five days old at 7·5° C., although the behaviour of older larvæ became more variable. Time spent swimming horizontally, vertically, and the distance swum vertically were recorded during each observation period. The positive photo-orthokinesis persisted in this apparatus. At lower light intensities (down to 3 m.c.) and also in red light (above 6500 A.) the larvæ swam only vertically upwards when active or sank passively. After a period in the dark, larvæ were always found in mid-water, so that they would appear to be active in total darkness, activity probably being at the basal

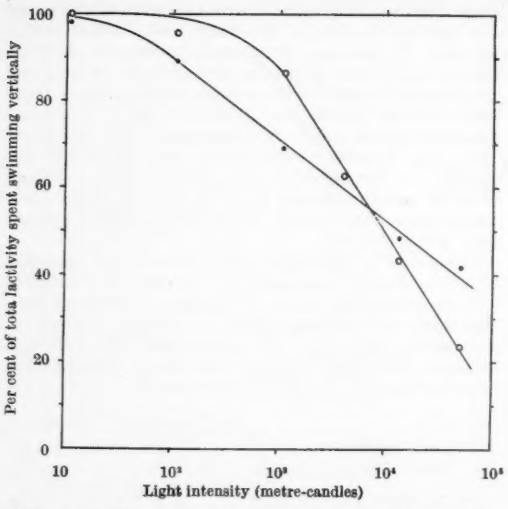

Fig. 1. Relation of change in orientation to light intensity for two typical larvæ

level observed at lower light intensities. At higher intensities (above 100 m.c.) larvæ also swam horizontally for part of the time active, this horizontal component increasing, together with the kinesis, finally increasing at the expense of the vertical component. The degree of change in orientation could be shown by expressing time spent swimming vertically as a percentage of the total time active and is directly related to the light intensity as shown (Fig. 1).

Since the change in orientation is definite, being at 90° to the light, it is assumed that the phototactic orientation is replaced by a dorsal light reaction at higher intensities. A dorsal light reaction has been demonstrated in several fish, and von Holst[2] has related the strength of this reaction to light intensity.

The reactions to light described fit the herring larva well for its environment. The larva is active in total darkness; this activity may be random, or vertically orientated as observed at lower light intensities; in the latter case it would be necessary to postulate a negative geotaxis[1] in addition to a positive phototaxis. The larva hatches from its demersal egg at low light intensities; activity directed vertically upwards either by a photo- or geo-taxis would take the larva towards the surface and higher light intensities. Once past a certain light threshold a larva will swim for a longer time and increasingly in a horizontal direction. This increase in the horizontal component will continue until the vertical component just compensates for passive sinking. Cushing[3] has suggested that the pattern of vertical migration consists of four parts; all four would be completed by the mechanism described, except that 'midnight sinking' would not occur if a negative geotaxis does indeed exist.

It is of considerable interest that such a mechanism of migration has recently been described by Harris[4] for a pond-living crustacean, *Daphnia magna*, although it would appear that the dorsal light reaction is of an all-or-none character in *D. magna*, as opposed to the finer mechanism of constant correction for sinking in the herring larva. The occurrence of similar mechanisms of depth control in planktonic animals so widely separated phylogenetically suggests that this type of behaviour may be of fairly widespread occurrence in the plankton community.

We wish to acknowledge our indebtedness to Mr. G. C. Bolster for very kindly supplying the herring larvæ.

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Rate of Milk Secretion with Increasing Interval between Milking

The belief that the rate of milk secretion declines with time during the interval between successive milkings is based on an observed increase from thrice daily and a decrease from once daily milking over normal twice daily milkings, and on Edwards's[1] calculations of secretion-rates in milking intervals of different length. Turner[2] recently questioned Edwards's conclusions on the grounds of the regression of residual on total milk yield and suggested that the secretion-rate does not decrease until after twenty hours. On the other hand, Bailey, Clough and Dodd[3] claim to have re-established that milk secretion rate does decrease with time.

Work on the problem has been undertaken at Ruakura in view of the fact that past results have been confused by a failure to hold constant the amount of residual milk, and further by the *a priori* belief that the length of the interval preceding each experimental interval may influence the measured secretion-rate.

In these Ruakura experiments, the measurement of secretion-rate *per se* has been aimed at by removal of residual milk with 10 I.U. of 'Pitocin' and by an experimental design which also eliminated any possible effect of the preceding interval. In addition, the design has permitted the measurement of preceding interval effect.

A balanced latin square has been used, an example of which follows, the intervals used being 4, 8, 12, 16, 20 and 24 hr.:

	Order of intervals					
Cows	1	2	3	4	5	6
1	8	20	16	4	12	24
2	20	4	24	8	16	12
3	16	24	20	12	8	4
4	4	8	12	20	24	16
5	12	16	8	24	4	20
6	24	12	4	16	20	8

To eliminate preceding interval effects, 12-hr. intervals were interposed between all the experimental intervals. It should be noted that the final result of any one square represents an aggregate of six cows. The design has the disadvantage that should the feed supply or the 'Pitocin' have an undue effect on milk secretion, or should there be a carry-over effect of preceding interval through the intervening twelve-hour interval, the result of any one animal may not be considered individually.

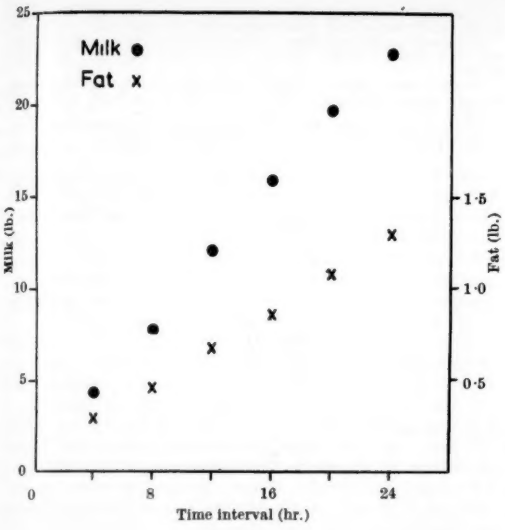

Fig. 1

Four trials have been carried out involving in each case six cows and using the design outlined above. In the first two trials the same six animals (second calvers) were used, the first being carried out when the animals averaged sixty-two days in milk, the second when 112 days in milk. The third and fourth trials involved a further twelve animals of varying ages averaging 135 days *post partum*.

Fig. 1 illustrates the type of result obtained (Trial 4). The other three experiments gave similar results. Both milk and fat secretion-rates showed no significant decline before 20–24 hr.

It is clear that up to an interval of approximately twenty hours neither milk nor fat secretion-rate decreased with increasing interval between milkings. The effect of an increase in length of the interval preceding the experimental interval was not clear-cut, but there were indications that increasing this period had a deleterious effect on rate of milk secretion and a beneficial effect on rate of fat secretion. Thus, the significant decrease obtained by Bailey *et al.* may be attributed, not to a direct pressure effect of increasing amount of milk in the udder, but to either or both of the two factors present in the Shinfield experiment and eliminated in the Ruakura experiment, namely, the effect of an increasing amount of residual milk and/or an increasing length of the preceding interval.

The significance of this conclusion in regard to the practices of milking at equal intervals and of milking three times a day is bound up with the action of these other two factors. So far as twice-daily milking is concerned, it may be suggested that unequal intervals, of a length indicated by the results of an experiment such as this, could be employed with no fear of a decrease in milk secretion due to direct pressure effects. A preliminary field trial at Ruakura using eight sets of identical twin cattle split between a 12–12 and 16–8 hourly milking regime and now in the final stages of lactation supports this contention. Similarly, observed increases with three times a day milking may not be the result of assumed reduction in udder pressure. Rather, the indications are that some other physiological function is involved. Both the Shinfield experiment and work at Ruakura indicate that such may be the case.

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[1] Edwards, J., *J. Agric. Sci.*, **40** (1950).
[2] Turner, H. G., *Aust. J. Agric. Res.*, **4**, 118 (1953).
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Site of Phosphorus Absorption in the Sheep

THOUGH several reports[1–4] deal with phosphorus uptake by the various divisions of the gastro-intestinal tract of the sheep, they do not compare the absorption of added physiological amounts of phosphorus from normal ingesta in these organs. To satisfy this requirement sheep were allowed to graze normally until approximately four hours before being anæsthetized. The organ under investigation was then tied off and radiophosphorus, in the form of orthophosphate with 1 mgm. per mc. carrier, injected into it. Blood samples were taken, at intervals, from the left jugular vein, and the plasma assayed for radioactivity in a dipping counter.

The graph (Fig. 1) shows the level of plasma activity, measured in μc./ml. per unit dose, plotted against time. The term unit dose refers to a dose of 66·7 μc. per litre of organ volume. This gives a rumen dose of 1 mc. Doses were calculated from organ volumes taken from Sisson[5].

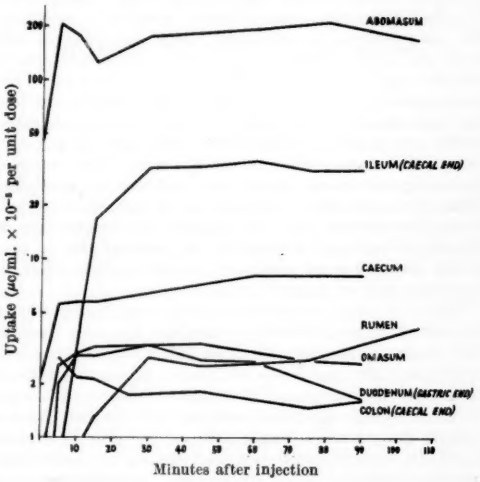

Fig. 1

The curves show that the absorption by the rumen, omasum, duodenum, colon and the cæcum are of the same order of magnitude. The apparently higher value for the cæcum is not considered significant. By contrast, absorption by the ileum is of an order ten times, and that by the abomasum one hundred times, greater.

The similarity of the figures for organs other than the ileum and abomasum suggests that the mechanism involved is one of simple exchange as distinct from true absorption by the latter.

The suggestion by Pathasarathy[6] that absorption occurs from the omasum is not supported by these figures.

This work is continuing and will be reported in full elsewhere.

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March 1.

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Plant Growth on 'Fly Ash'

The difficulties of the satisfactory disposal of the pulverized fuel waste from power station boilers, often referred to as fly ash, is world wide. In Britain the problem is particularly acute, especially where agricultural land is used for its disposal[1]. The present findings are the result of an intensive study of crop problems which are likely to be encountered when attempts are made to revegetate areas of agricultural importance which have become contaminated with this waste product.

Preliminary field-observation had suggested that the ash might contain certain substances which seriously retard the growth of plants. Indeed, the common weeds which rapidly establish themselves on other industrial wastes seem unable to colonize this material with probably three exceptions, the most successful being the chenopodiaceous plant *Atriplex hastata* var. *deltoidea* (hastate orache). This plant quickly forms practically pure stands on the bare ash when other weeds and rough grasses are completely excluded. It seems, therefore, that the properties of the ash which seriously affect the normal physiology of most plants are resisted by *Atriplex*. These circumstances would appear to afford an opportunity for further contributions to our knowledge of the physiology and autecology of ruderal plants, and at the same time to produce valuable information on the plant/ash nutrient relationships.

Chemical analyses of the main constituents of the fly ash are periodically published by the Central Electricity Authority; but as yet no attempt seems to have been made to examine its plant nutrient properties as compared with those of a normal soil. Detailed spectrographic analysis of the ash and a typical soil, kindly made for us by the Macaulay Institute, together with our own exhaustive analytical studies, indicate that aluminium, manganese, iron and nickel only are present in quantities toxic to plants. Other potential toxins present, for example, zinc, cobalt, chromium and titanium, at first suspected, in all probability exist in harmless quantities. Of the major plant nutrients, nitrogen alone appears deficient, forming some 0·04 per cent of the oven-dried ash.

Sand culture experiments with barley using the following levels of toxic metals: aluminium, 3 meq., manganese, 3 meq., nickel, 1 meq., and iron, 1 meq., in one litre of ordinary culture solution, singly and in all combinations, produced the following symptoms:

Aluminium: stunting, lack of tillering; purplish tint on stems; erect pointed leaves with brown brittle tips and die back.
Manganese: slight stunting; leaves with brown tips and die back and dark brown spotting on the lamina later coalescing as brown streaks.
Nickel: plants severely stunted and chlorotic; leaves with white necrotic areas beginning in the middle of the leaf and causing its collapse.
Iron: Slight purplish tint, otherwise growth as per control.
Metals in combinations produced additive symptoms.

Barley grown on ash to which a full culture solution had been added developed symptoms identical with those produced in the sand culture which contained manganese and aluminium. No nickel symptoms were produced. On the other hand, *Atriplex* grew normally in sand culture containing aluminium, manganese and iron at toxic levels, but was severely stunted and chlorotic when nickel was added.

In another series of culture experiments, a number of crop plants were grown in an ash/culture medium. The plants selected have been shown by Hewitt[2] to be sensitive indicators of toxic levels of aluminium and manganese alone or in combination. In all cases the ash induced symptoms comparable to those described by Hewitt. These findings were confirmed by tissue analyses. Plants grown on ash always showed an excess uptake of manganese and aluminium as compared with the controls.

Water-culture experiments using different levels of nitrogen have shown that *Atriplex*, in contrast to crop plants, can tolerate low levels of nitrogen without effect on its normal growth.

We thank Dr. E. J. Hewitt, of Long Ashton, for his help, and the Central Electricity Authority for providing facilities for field-studies. A fuller account will be published elsewhere.

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Œstrus in Zebu Cattle in Uganda

During investigations into the possibility of artificial insemination of indigenous Zebu and Nganda cattle with homologous semen obtained by electrical stimulation, the œstrous cycles of an experimental group of heifers have been determined, using marked vasectomized bulls. The animals have been examined for evidence of service at 0700 and 1900 hr. local time. In two months, œstrus has been detected in five animals on fifteen occasions; but marking by the bull has never occurred on less than two occasions. These were recorded as of 12 hours duration (0700–1900 hr., and vice versa). Based on this marking of the females, three heat periods lasted 12 hr., nine lasted 24 hr., two lasted 36 hr. and one lasted 48 hr. Of this total, six (40 per cent) were first recorded at 0700 hr. (commenced during darkness), and nine were first recorded at 1900 hr. (commenced during daylight).

More recently, during observations of the habits of Zebu cattle[1], two cows have been observed in detail throughout œstrus, and these observations have helped to explain the above results. Our observations show that the cows are attractive to the bull for some hours before and after they are ready to accept service. Thus in one instance the bull detected the

cow 4 hr. 33 min. before she would accept service, and during the last 1 hr. 44 min. of this period, sixteen attempts to serve were made. One service only was allowed; but the bull's interest continued for a further 9 hr. 37 min. In the second instance, the bull detected the cow 10 hr. 24 min. before service was allowed. The cow then permitted service twice in 16 min., and the bull continued to attempt service for a further six hours; in fact, serving the cow once again 2 hr. 12 min. after the preceding services, when the cow was no longer truly receptive.

These results are of interest, for they agree with field-observations that African cattle owners may successfully walk cows several miles 'to the bull', but differ from previous scientific work in some respects. The observations suggest that while the duration of œstrus is short in the Zebu at Entebbe, the period of pro-œstrus is much longer than the 44–63 min. reported in Kenya[2], the behaviour of the female remaining at stage 1 and 2 of œstrus[3] for a considerable period before and after œstrus. These results are more in agreement with South African workers[4], who found the mean duration of onset of œstrus in indigenous Afrikander cows to be 7·46 hr. (range 0–24 hr.), and the average time of the disappearance of œstrus 5·73 hr. (range 0–18 hr.).

The proportion of animals coming into œstrus during darkness (40 per cent) is very similar to that reported in Kenya[2] (31·3 per cent, allowing one-third for 1 hr. difference between 0600 and 0700 hr. within the period of observation, 0600–0900 hr.). It has been reported that at the Messina Experiment Station in South Africa[5], 90 per cent of œstrus commenced between midnight and 0900 hr. This compares with 45·3 per cent in Kenya[2] for the identical time. On the other hand, in Sweden[6] it has been reported that 43 per cent of œstrus commenced during daylight and 57 per cent during darkness.

The duration of œstrus in the above two observations is very similar to that reported from Kenya[2,7] and shorter than that reported for South Africa[4] (7·88 hr., range 1–14 hr., indigenous Afrikander), or in the Philippines[8], where a mean of 13·3 hr. (range 5·5–22·4 hr.) was recorded for native cattle.

There are marked climatic differences between Entebbe and the sites of the stations where the observations referred to above were made. The climate at Entebbe (altitude 3,780 ft.) is very equable, with a well-distributed rainfall (average 59 in.), and humidity frequently high due to the proximity of Lake Victoria[9]. The latitude of 0° 02′ N. gives little variation in length of daylight.

It is hoped to extend and report these findings in further detail at a later date.

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Reaction to Light of Iris-Chromatophores

Field workroom observations in this Sanctuary show that intensity of daylight controls reaction of chromatophore cells in irises of the male duck *Netta erythropthalma* (Wied.). A minor field characteristic of the male African pochard is the brilliant vermilion iris—a feature easily discernible with binoculars at up to about a hundred yards. The female's irises are umber.

Timed observation revealed, on taking the male from a lightproof box in a daylit workroom to the window:

0 min.	Irises dull yellow ochre
1 ,,	First suggestion of red suffused: no noticeable pattern
2·5 ,,	Irises much warmer and darker
3 ,,	Red area extends; grows stronger
4 ,,	Irises nearly all red
5 ,,	Irises 'normal'. Brilliant vermilion suffused over dull ochre background

The radical reaction of chromatophores occurs simultaneously in various parts of the iris. When colour-change is apparently complete there remain pinpoints of ochre. The action commences before pupils have completely contracted.

Further field-work is in progress, and laboratory examination of the eyes will be carried out. Other members of Anatidae are being subjected to examination.

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Two New Mutations in the Syrian Hamster

The Syrian hamster, *Mesocricetus auratus*, introduced to the laboratory by Adler and Theodor[1] in 1931, is a golden-brown rodent with pale cream belly fur and two characteristic throat flashes. Melanic pigment darkens the skin of the ears and is present about the genitals in both sexes (in the region of the vulva and anus in females, and in the scrotum and spots on the prepuce in males). It is to be expected, as increasing numbers of hamsters are bred, that mutant types will appear. This note records the occurrence of two new mutations.

Cream (proposed symbol *e*). The cream is devoid of melanic pigmentation in the fur but retains the skin colouring present in the ears, genitals and hip-gland. The eyes are dark. The coat colour is a rich creamy yellow, lighter on the belly than on the dorsum. Growth, viability and fertility are comparable to the normal. Reciprocal matings of cream × normal produced a normal F_1 and an F_2 segregation of 154 normal and 58 cream ($\chi_1^2 = 0{\cdot}629$; $P = 0{\cdot}5 - 0{\cdot}3$). An autosomal recessive is apparently involved with normal penetrance and viability.

Ruby-eye (proposed symbol *ru*). The coat colour of ruby-eye animals is distinctly weakened. Both black and yellow are affected; the black to bluish and the yellow to fawn. The skin colour is appreciably paler and develops much later in the young animal. New-born animals display an annulus of pigment in the iris, clearly visible beneath the closed eyelids. When the eyes open, the pupil possesses a ruby mien in most but dull lights. As adults, the ears are faintly pigmented while the genitals are

usually flesh pink. Growth-rate, viability and fecundity are all subnormal. Adult size is reduced in both sexes and the males are frequently sterile. The F_1 of normal ♂♂ × ruby-eye ♀♀ are normal and an F_2 segregated into 220 normal and 35 ruby-eyed ($\chi^2_1 = 17{\cdot}29$; $P < 0{\cdot}001$). There is a significant deficiency of ruby-eyed individuals for the assumptive inheritance of an autosomal recessive gene. Impenetrance is considered improbable since the distinction between normal and ruby-eye is sharply defined; there is no intergrading.

The estimated viability of ruby-eye homozygotes is $0{\cdot}477 \pm 0{\cdot}087$ at the recording age of twenty-one days. The lowered viability could be the result of the interplay of several factors: (1) the perishing of some *ru*-bearing gametes; (2) the selective degeneration of some *ruru* fœtuses (since these probably have impaired growth); (3) a greater proneness for *ruru* young to succumb during parturition; (4) selective cannibalism of *ruru* young by the mother (again possible as a consequence of the impaired growth-rate). It may be remarked that no obviously inferior *ruru* young could be detected at birth; unfortunately the mothers resent viciously the handling of new-born young, making detailed scrutiny hazardous for the litter.

All new-born litters are examined as soon as possible after birth, thus (4) could be partitioned into (*a*) cannibalism prior to examination and (*b*) cannibalism later. The latter usually occurs within 1–3 days. Only this last factor can be analysed with the present material. If selective cannibalism occurs, it is to be expected that in litters with no or little observed cannibalism, the proportion of ruby-eye should approach more closely to a 3 : 1 ratio. The pertinent data are shown in Table 1.

Table 1. Number of Young Eaten per Litter

Phenotype	0	1	2	3	4	5	6	7
Ru⁻	54	80	54	12	4	0	5	11
ruru	9	8	12	3	0	0	1	2

Total number of young in litter with degrees of cannibalism or losses.

To apply a test for heterogeneity, the five classes on the right were merged, resulting in a χ^2_3 of 6·12; $P = 0{\cdot}20 - 0{\cdot}10$. The data clearly fail to substantiate a claim of selective cannibalism of type 4*b*. The most favoured explanation is that of (2)—a relatively greater propensity for *ruru* fœtuses to atrophy in face of *in uteri* competition.

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Chromosome Number of Human Cervix Uteri

In a recent review, Beatty[1] has shown much evidence in favour of the inconstancy of chromosome number in various somatic tissues of mammals, including man. Sachs[2], however, did not observe any variation in the chromosome number of human and some other mammalian endometrial tissues from a count of fifty nuclei in each case by using the squash technique. Walker and Boothroyd[3], using a similar method, obtained wide variations in the chromosome number in somatic tissues of mouse and to a less extent in human endometrium; but when they employed the membrane and spinning technique[3] for the same tissues, the variations were within a narrow limit. Human endometrial tissues have also been examined by me[4] and by Timonen[5]. Except Sachs[2], we have found variation of the chromosome number in human endometrium, although my results[4] agree more with those of Walker and Boothroyd[3] in showing a narrower range of variation than those of Timonen[5]. Since the chromosome number of human endometrium is a matter of controversy, I have been studying the chromosome in the epithelium of non-neoplastic cervix uteri with an improved technique[6]. Preliminary results for chromosome counts from one hundred nuclei have been obtained.

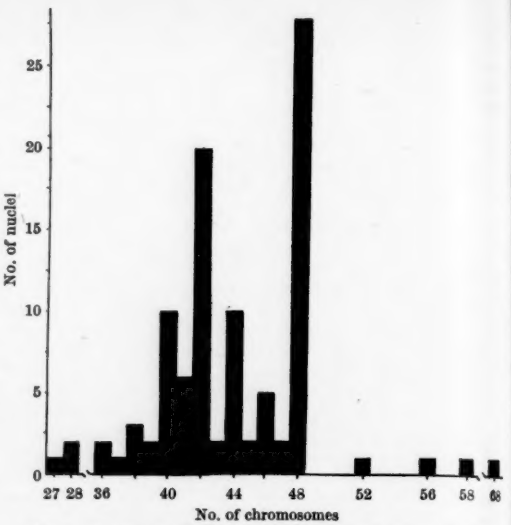

Fig. 1. Frequency distribution of chromosome number in cells from human cervix uteri

The distribution of the chromosome numbers in the present work ranges from 27 to 68 (Fig. 1). Of 100 nuclei, four had the following hyperdiploid numbers: 52, 56, 58 and 68 chromosomes, twenty-eight nuclei had the normal diploid set, and the remaining sixty-eight nuclei had subdiploid numbers (fifty-seven of them had numbers ranging between 40 and 47). The frequency distribution peak was found at the diploid number, but there was also another lower peak at 42.

Some error in counting may have occurred owing to technical difficulties; but this has been minimized by various recent techniques. Hence it must be concluded that variations occur in the chromosome number of normal somatic tissues of man and mammals. The results obtained with somatic tissues by various workers[1] and in the present work show that the same somatic tissue may have a different chromosome number distribution in different cells at different times, and this will be more apparent when periodic regeneration and degeneration takes place[4] and mitotic abnormalities are not infrequent. In our study of human cervix tissue there is some indication of the existence of difference in the frequency distribution of chromosome numbers in different patients; further results will be necessary to substantiate it.

I am indebted to Dr. S. P. Ray-Chaudhuri, of the University of Calcutta, for his initiation of the present study, and to Dr. Subodh Mitra, director of the Chittaranjan Cancer Hospital, Calcutta, for his interest.

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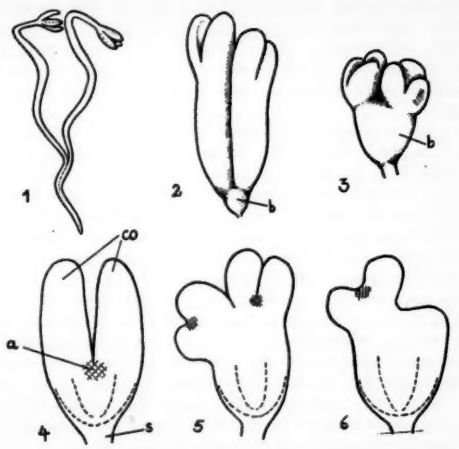
Experimentally Induced Twinning in Plants

It is well known that characteristic changes in leaf-form and growth habit can be induced by treating shoot apices with synthetic growth substances. The question arises as to whether entire plant embryos also can be induced to develop abnormally by the action of growth regulators. For this purpose the solutions must be applied in a suitable manner to the earliest embryo stages through the growing carpel walls, or it would be necessary to remove the still quite small embryos and to expose them *in vitro* to the proper influences. Both methods are difficult to apply and have as yet proved unsatisfactory.

These difficulties can be overcome by using especially suitable material, such as mature seeds of *Eranthis hiemalis* L. *Eranthis*, in common with several other spring-flowering plants, discharges its seeds, which outwardly appear to be mature but which really contain only undifferentiated pear-shaped embryos. The development of the embryos occurs between May and December in the seeds lying in the soil[1]. Consequently, the still very small embryos in the freshly collected seeds can be exposed to the desired treatments. By successive removal of the embryos during the summer and autumn, all stages of normal and experimentally altered development can be observed.

The experiments, which were begun in 1953 and which have been continued to date, were carried out in the following manner. The freshly collected seeds were either submerged for 12–14 hr. in solutions of the active substances or were planted out in flower-pots in groups of a hundred each, and 50 c.c. of the solution was poured on. A 0·1 per cent solution of 2,4-dichlorophenoxyacetic acid caused almost 100 per cent cotyledon anomalies (syncotyly and pleiocotyly of all degrees); this contrasts with only 0·37 per cent in untreated material[2]. In addition, there was always a certain percentage (3–8) of twinning. The normal rate of twinning in *Eranthis hiemalis* is approximately 0·03 per cent. The twins were almost always fused at the base in varying degree and frequently showed cotyledon anomalies (Fig. 1). 2,4,5-Trichlorophenoxyacetic acid and α-naphthalene acetic acid produced a similar effect within the same range of concentration. With lower solution concentrations (less than 0·1 per cent) the number of anomalies decreased, while in the case of concentrations of more than 0·2 per cent lethal deformities increased.



Figs. 1–6. *Eranthis hiemalis*. (1), Twin seedling; (2 and 3) twin embryos removed in September and towards the end of June (× 110 and × 200, respectively); (4–6) longitudinal sections; (4) normally developed embryo, (5 and 6) embryos with two- and one-sided regeneration (× 280). *a*, apex; *b*, pear-shaped body; *co*, cotyledons; *s*, suspensor

In order to obtain information on the mechanism of twin origin, which is apparently the result of cleavage, various developmental stages were subjected to anatomical investigation. Fig. 2 shows a pair of twins removed from the seed in September. Here again both embryos are fused together at the root end. They originate from a pear-shaped body (*b*), the shape of which suggests that it is the original embryo itself which has regenerated two new embryos. This assumption is strengthened by viewing a still younger twin stage, as can be obtained towards the end of June (Fig. 3). Where normally both primordial cotyledons would be expected (Fig. 4), two new embryo buds with three cotyledons each have developed. A longitudinal section of the same embryo shows the relationships in a still more clear-cut manner (Fig. 5). The original embryo has developed normally in its basal part; the suspensor (*s*), the initial root cap and the new cell divisions of the procambial cylinder can be seen. However, the centrally located shoot apex is completely lacking and, in place of both cotyledons, two new embryonic upper parts with apices and cotyledon primordia have formed.

The following hypothesis may be advanced. The still undifferentiated embryo, such as is present when treatments are being carried on, already possesses an 'apical dominance'. The group of cells out of which the shoot apex later arises inhibits (either competitively or regulatively) the formation of further apices. These cells of the embryo apex are especially likely to be damaged due to the action of synthetic growth substances on the pear-shaped embryo. In this manner their influence disappears, and the cells which normally would give rise to the cotyledons grow into new stem tips.

Now we would expect, on the basis of our knowledge of correlation phenomena, that the regenerative formation of two new shoot apices would occur relatively infrequently and that a slight precocity in the one would necessarily inhibit the formation of the other. Such is the case of the embryo in Fig. 6. In place of the one cotyledon an embryonic bud has arisen while, on the opposite side, where the other

cotyledon would be expected, only a few rather closely clustered nuclei suggest a short activity period. Embryos with one-sided regeneration were encountered in our material exceptionally frequently. This would tend to support our hypothesis.

In this connexion we must refer to the results of Wardlaw and Cutter[3-6]. When in the apical cone of *Dryopteris austriaca* the positions of the youngest visible primordia or of the site of the next primordium were partially isolated from the shoot apical cell by two wide tangential incisions, buds instead of leaves are formed. E. Ball[7] also obtained in *Lupinus albus*, after destroying the central portion of the shoot apex, one or two new apices by divisions of the second tunica layer in a flank position. Contrary to the results of Wardlaw in ferns, we have not observed the transformation of an already visible cotyledon primordium into a new stem apex. Treatment which occurred later than ten days after the discharge of the seeds produced no more twins, because at this time the cotyledon primordia began to differentiate.

The illustrations are based on photographic illustrations; these last will appear in a more comprehensive work to be published later.

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Displacement Activities in Fiddler Crabs

According to Tinbergen[1], a "displacement activity is an activity belonging to the executive motor pattern of an instinct other than the instinct(s) activated", and, according to Bastock, Morris and Moynihan[2], such activities would seem to take place in two quite different situations: "(1) Displacement activities may be performed by an animal in which two or more incompatible drives are strongly activated. Each drive prevents the expression of the other(s). (2) Displacement activities may also be performed by an animal in which one drive is, at the same time, both activated and thwarted."

Displacement activities have been reported for various vertebrates, especially fish and birds. Morris[3], for example, recently described the displacement activities of the zebra finch, *Poephila guttata*.

To the best of my knowledge, no case of a displacement activity has yet been recorded for an invertebrate. However, a recent study of the behaviour of the fiddler crabs (*Uca* spp.) which occupy the mangrove swamps of Inhaca Island, off the coast of Mozambique, revealed a number of instances of displacement feeding.

For normal feeding, male *Uca* crabs use only their spooned minor cheliped, the enlarged major cheliped being held at rest. With the minor cheliped, the crab scoops up from the ground a mixture of sand or mud and organic particles, which is then conveyed to the mouth. The mouthparts separate out the organic particles until, eventually, enough sand has collected to form a pellet, which drops to the ground. The female crabs differ from the males in that they possess no enlarged cheliped, but use their two small chelipeds more or less alternately during the feeding process.

(1) Displacement feeding as a result of a conflict of incompatible drives—the drive to attack and the drive to flee—was noticed in the following four species: *U. annulipes*, *U. chlorophthalmus*, *U. marionis* and *U. urvillei*. While protecting their burrows from male intruders or being threatened by superior males, and especially between bouts of actual fighting (in all of which activities the use of the major cheliped is involved), male crabs were seen to be feeding rather agitatedly. Such individuals appeared to be highly 'nervous', the scooping movements of their minor cheliped being far more frequent and far less deliberate than those of normal feeding. During displacement feeding a negligible quantity of food actually seemed to reach the mouth—not sufficient for any sand pellets to be formed. In the field it was noticed that the majority of individuals of all the species showing displacement activity were males. Females are, generally speaking, rather timid, for—possessing no major cheliped—they are ill-equipped for fighting. If threatened by a male, they can usually manage to escape by scurrying off to disappear down their burrows; that is, in such a case, only their escape-drive is stimulated, so that no tense conflict of drives is involved, and, hence, no displacement activity is produced.

(2) Displacement activities due to the simultaneous activation and thwarting of the same drive were observed in *U. marionis*, *U. urvillei*, *U. annulipes* and *U. chlorophthalmus*, during their respective mating seasons. This type of displacement feeding was particularly noticeable in *U. marionis* and *U. urvillei*, for these species were observed when their breeding season was far advanced. *U. annulipes* and *U. chlorophthalmus*, however, were under observation when their courtship was only in its incipient stages, so that displacement activity was noticed only occasionally. Generally speaking, during the breeding season, the approach of a female frequently stimulated a male, causing him to beckon with his major cheliped several times in quick succession, in a manner characteristic of his species. In *U. marionis* males, especially, such courtship display often appeared to become very intense, with each beckoning individual standing on the very tips of his ambulatories and running a short distance to the left and then to the right, repeatedly, between individual beckoning movements. Frequently a female would appear to respond to such display by leading the male to her burrow and, perhaps, by allowing the male to stroke her carapace. Now and again, however, the display of a male crab was ignored by the female, who either continued to feed quite normally or disappeared temporarily down her burrow. In such a case, if the thwarted male were sufficiently aroused sexually, he would frequently begin to show displacement feeding, until the female concerned took notice of him, either by stopping her feeding or by reappearing from her burrow, or until, perhaps, the approach of another female distracted his attention. Thus, periods of displacement activity were often found alternating with periods of intense courtship display.

Under laboratory conditions, displacement feeding was observed in *U. inversa*. In the field, the burrows of this species are rather widely spaced, with the result that fighting over the ownership of territories is unnecessary, and, therefore, relatively rare. Hence,

displacement activities are also at a minimum. However, it appeared that several *U. inversa* individuals, confined to a terrarium too small for their number, became unnaturally aggressive towards one another. Of these, one female was seen to be performing displacement feeding—the one and only case of a displacement activity observed in this particular species. The female concerned appeared to be trapped in a corner, away from her burrow, and completely surrounded by four males. She ran about nervously, trying unsuccessfully to make her escape, and even attempted to climb the vertical sides of the terrarium, falling down again and again. Finally, she began to feed, in a highly 'nervous' fashion, and, since her chelipeds appeared to be scooping up no mud whatsoever, it appears that this must be yet another case of displacement feeding.

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Cytochemical Research on Coelenterate Nematocysts

A NOTE by T. M. Yanagita and T. Wada[1] suggesting, after C. H. Brown[2], the possible keratin nature of coelenterate nematocysts has directed my attention to the subject. In 1952 I had observed the pronounced metachromatic colour produced by dilute thionin on large nematocysts from a siphonophore, *Halistemma* sp. It is known that the metachromatic colour of a dye, as taken up by a substance, is characteristic of an acidic mucopolysaccharide content, associated or not, with proteins to form mucoproteins[3]. The fact interested me, since I had studied such substances in the envelopes of pagurid and cephalopod spermatophores[4].

Another aspect of the nematocyst's contents has been studied by J. Boisseau[5]—the presumably toxic substance enclosed in the cnidocyst. He concludes that an albumin content is associated with a phenolic compound; the latter differs according to the type of cnidocyst and the species investigated.

In view of these different facts, I undertook to investigate the matter more closely, with the few cytochemical procedures available to me. Two species were chosen: a siphonophore, *Abylopsis tetragona* Ott. (*Halistemma* are not as frequent off the coast of Algiers), and an actinian, *Anemonia sulcata* Penn.

(1) *Abylopsis* has four types of nematocysts localized in the dactylozooid; I shall use Weill's[6] nomenclature to designate them eventually. I ascertained the protein constituent by means of a few colour reactions which are weakly positive (ninhydrin, Sakagushi, Millon, Adamkiewicz). The cystine content was revealed by the lead sulphide reaction. It is positive on every part of all cnidocysts, thereby confirming my predecessors' findings. The phenolic group was studied with the azo and chromaffine reactions and others special to *ortho*diphenols, according to procedures given by Lison[7]. I found that all nematocysts contain a small amount of *ortho*diphenol. This may differ according to the parts of the cyst.

The mucopolysaccharide content was analysed by means of techniques summarized by Lison[7]. The different kinds of cysts react positively to the Bauer test. Staining with toluidine blue gives different results: the invaginated (or discharged) threads and fluid content of the cnidocysts take a strongly metachromatic hue, implying the presence of a sulphomucopolysaccharide compound; the mastigophore capsules alone are to a lesser degree metachromatic too: this would indicate a simple mucopolysaccharide content (as defined by K. Meyer[3]). The other nematocyst capsules are coloured orthochromatically. They can, however, be made to colour metachromatically by treatment with 10 per cent chromic acid. These capsules would thus contain a neutral mucoprotein.

(2) *Anemonia sulcata* has several kinds of nematocysts, localized in different parts of the body. There are, besides, spirocysts in the tentacles, not considered to be true cnidocysts (Weill[6]). The protein content includes arginine, specially abundant in spirocysts, on which it confers basic properties; tryptophan is present in small quantity; cystine can be revealed by the lead sulphide and by the sodium nitroprussate reactions—the latter after reducing the S—S linkage in the amino-acid. The result is more strongly positive on the spirocysts than on the basitrichia or other kinds. The Chevremont and Fredericq test could not be of any use in this case, since it is given by other reducing agents, such as diphenols. It is likely the S—S bridges in the protein account for the sensitivity of certain parts to alkaline sodium sulphide, such as was found by Brown[3] and which I confirmed on the basitrichia capsules. The spirocysts are not wholly soluble.

The presence of an *ortho*diphenol has been identified in each type of nematocyst; the amount is very slight, as shown by the weak chromaffine reaction. The spirocysts contain an amino-*ortho*diphenol instead (giving a positive azo-reaction in acidic medium, as well as in alkaline solution).

The polysaccharide content gives a positive Bauer reaction, but as a rule very faint. Staining by toluidine blue is not strongly metachromatic on basitrichia and the contents of atrichia, since colour is due to the carboxylic groups. These nematocysts seem to be made of simple mucoproteins. But the mastigophores and atrichia capsules are not coloured; neither are the spirocysts, which, being acidophilic, do not take basic dyes. The two former can, however, be made to stain metachromatically after chromic oxidation. This would indicate that they are made up of neutral mucoproteins. The spirocysts remain uncoloured in these conditions; since they are slightly Bauer-positive, I think this indicates a low polysaccharide content linked to a basic protein. I would suggest it is a glycoprotein, as defined by Meyer[3], on account of its low carbohydrate content.

A more detailed account will be published elsewhere.

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Side-Chain Orientation in Fibrous Proteins

The specific properties of proteins depend to a large extent upon the composition and arrangement of their side-chains, and a good deal of information has been accumulated recently on the amino-acid sequences of various proteins. Very little is known, however, of the stereochemistry of the side-chain residues and the relations between side-chain configuration and orientation and the specific properties they confer on proteins. This is largely due to the lack of direct evidence, since X-ray diffraction diagrams obtained from fibrous proteins emphasize only the similarities between the configuration of the polypeptide backbone chain, while the very much richer diffraction patterns obtained from crystalline globular proteins have, as yet, only been interpreted in very general terms[1].

In view of the paucity of information concerning side-chain orientation, Elliott's deduction[2] of a marked preference for the side-chain amide groups in crystalline ribonuclease to orient, with the HH direction parallel to the *b* crystallographic axis, is important because of the very direct nature of the experimental evidence. The preferred orientation was deduced from the dichroism exhibited by an absorption band about 5,050 cm.$^{-1}$ in the infra-red spectrum in which the associated transition moment was assumed to be parallel to the HH direction. Elliott also showed[3] that in the spectrum of horse hair dried *in vacuo* an incompletely resolved band near this frequency was dichroic, but precise observation was hampered by an overlapping absorption band about 5,150 cm.$^{-1}$ due to residual water in the specimen.

It has been found that the 5,150 cm.$^{-1}$ absorption band can be completely eliminated from the spectra of fibrous proteins by drying at 105° C. for three hours, thus enabling the 5,050 cm.$^{-1}$ absorption band to be studied in some detail. Fig. 1 shows the spectra of Lincoln wool, silk fibroin, gliadin and human hair extended 90 per cent in steam all dried in the above manner and immersed in hexachlorobutadiene. The assignment of the 5,050 cm.$^{-1}$ band to side-chain amide groups is confirmed by its relative prominence in silk, wool and gliadin, which is in accord with the amide nitrogen contents of the specimens used. Expressed as percentages of the total nitrogen, these were 1·2, 6·8 and 24·2 respectively[4].

The strong perpendicular dichroism of the side-chain amide band in wool, which is also found in unstretched hair, indicates a marked tendency for the $-CONH_2$ groups to be oriented with the line joining the two hydrogen atoms perpendicular to the fibre axis, and this is depicted diagrammatically in Fig. 2. The orientation about the HH line cannot be fixed by this observation alone; but that shown in Fig. 2 would be particularly important in establishing intermolecular hydrogen bonds. In addition, this orientation would appear to permit the formation of hydrogen bonds to the side-chains of two neighbouring polypeptide chains through the agency of a single amide group.

In hair that has been extended 90 per cent in steam the dichroism of the side-chain amide band vanishes, even though the neighbouring peptide absorption band shows considerable dichroism. The loss of dichroism could be due to a re-orientation of the amide group such that the direction of the transition moment is inclined at about 55° to the fibre axis[5]; but it seems more likely to be due to a random

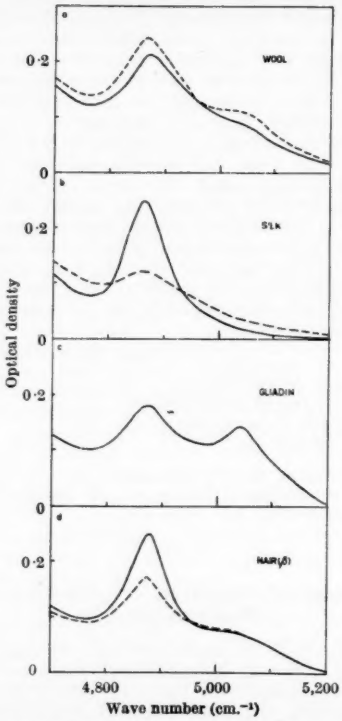

Fig. 1. Infra-red spectra obtained from (*a*) Lincoln wool fibres, (*b*) silk fibroin, (*c*) powdered gliadin and (*d*) human hair stretched 90 per cent in steam. In each case the specimen was dried at 105° C. for 3 hr., to reveal the side-chain amide absorption *c*. 5,050 cm.$^{-1}$. In *a*, *b* and *d*, the full curve was obtained with the electric vector vibrating parallel to the fibre axis and the broken curve with the electric vector perpendicular

orientation of the HH direction in the extended condition.

Additional information on the site of the amide side-chains was obtained by allowing oven-dry wool to react with deuterium oxide. The replacement of hydrogen by deuterium causes a considerable reduction in frequency of vibrations involving hydrogen atoms, thus indicating the accessibility of particular groups to deuterium oxide[6]. After 16 hr. immersion at 20° C. the optical density of the peptide band at 4,870 cm.$^{-1}$ was reduced to about one-half of its original value, while the amide band was no longer detectable.

It has been assumed that the fraction inaccessible to deuterium oxide is crystalline, and this forms the basis of a method of determining the crystallinity of wool[7]. If this is correct, the side-chain amide groups

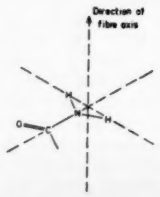

Fig. 2. The relation between the direction of the fibre axis and that of a line joining the two hydrogen atoms of the side-chain amide groups in wool and hair deduced from the perpendicular dichroism of the 5,050 cm.$^{-1}$ absorption band

must be concentrated in the amorphous regions of the fibre but at points where there is considerable preferred orientation of the molecular chains parallel to the fibre axis.

It is implicitly assumed, in the above method of determining crystallinity, that there is a uniform distribution of side-chains throughout the crystalline and amorphous regions. In view of the complete exchange of the amide groups, this assumption does not appear to be valid and the values of crystallinity obtained by this method are probably too low.

Alternatively, it might be argued that amide groups are present in the crystalline regions but are accessible to deuterium oxide, and this would be consistent with the infra-red measurements. In this case the basis of the deuterium exchange method of determining crystallinity would then be invalidated.

Of the two interpretations the former is the more attractive, as the amide-containing side-chains are relatively bulky and might be expected, from recent work on silk[8], to be concentrated in the amorphous regions.

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Reverse-Shearing Interferometry

The introduction of the shearing principle in the examination of optical wave-fronts by interferometry[1] has led to a great simplification of the apparatus required. Recent developments[2,3] have made possible the construction of compact portable interferometers for the examination of optical systems of large size, and several instruments are now available from optical manufacturers. For some purposes, however, it is possible to use as a shearing interferometer an even simpler system which is already in wide use for another purpose. This is the square prism used in photometry for dividing a beam of light into two. It is composed of two similar right-angled prisms cemented at their hypotenuse faces after one face has been coated with a semi-reflecting film. An application of this prism to the interferometry of length was first described by Kösters[4], but the prism is also very useful as a shearing interferometer.

Two alternative arrangements may be used if the system is a reflecting one; these are shown in Fig. 1. The source S may be the filament of a small flashlamp bulb, or an illuminated pinhole; in some cases the reflexion of a distant window or lamp in the convex surface of a steel ball will provide a suitable source. The system shown is a concave mirror, M, arranged so that the light from S which emerges from the prism is reflected back into the prism. The original beam is split into two at the interface during its passage through the prism, and each of these parts is split again in the prism after reflexion at the system under test. Thus four beams finally emerge from the prism. Two are directed towards the source S, and the position of M is adjusted until they both produce an image of S coincident with S. Then the remaining two beams will form two more images of S, which coincide, at S'. If the eye is placed at S' looking into the prism, two images of the aperture of M are seen. One of these images is a mirror image of the other, and the region in which they overlap is crossed by interference bands. The overlap of the images may be controlled by rotating the prism, and the separation of the bands may be altered by tilting M.

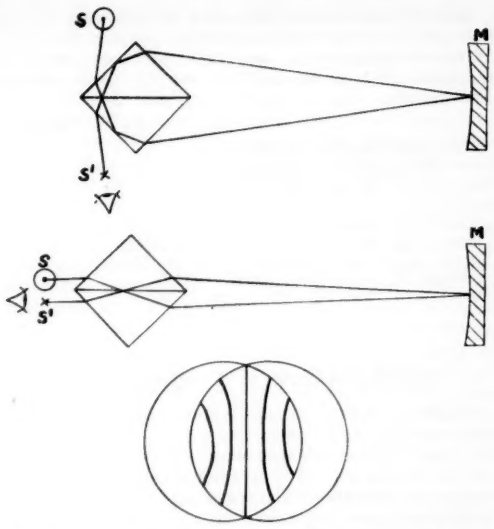

Fig. 1. Two alternative arrangements for using a beam-splitting prism as a shearing interferometer, and an example of a pattern produced by a system with 0·25 wave-length of primary spherical aberration

Systems such as camera lenses, which do not reflect, can be examined by using a second beam-splitting prism to recombine the two beams produced by the first prism; but it is simpler and gives a more sensitive test of aberration to place a mirror behind the lens and to treat the lens and mirror combination as a reflecting system.

When the two images of the aperture of the system appear to coincide (zero shear) the bands should be quite straight. Any lack of straightness shows a lack of mirror symmetry in the wave-front after reflexion at M. If the test is repeated for a few meridians, and the bands remain straight in all cases, the surface of M must be a surface of revolution, and Bates's[1] procedure for the analysis of the interferograms obtained by shearing the apertures may be followed. Further, the pattern which is obtained from a reverse-shearing interferometer will be exactly the same as one which could be obtained from a non-reversing interferometer with the same shear.

The main disadvantage in the use of this prism is common to all 'solid' interferometers, and arises from the difficulty of adjusting the band separation in a direction at right angles to the direction of shear. On the other hand, the compactness of the system is noteworthy, and the interferometer remains sensitive to comatic error at zero shear, when all symmetrical aberrations have no effect on the pattern. This latter property has been investigated in more detail and will be reported elsewhere[5].

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

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Embrittlement of Tungsten Wire

The embrittlement of tungsten wire heaters for oxide cathodes has been a frequent source of trouble to the vacuum-tube engineer. The trouble has persisted despite the many technological advances made in the manufacture of the wire and in its subsequent handling.

In the processing of a heater the wire is coated with a refractory oxide (normally alumina) and the coating fired to hardness in an atmosphere of wet hydrogen at a temperature usually above 1,500° C. It is customary to test the quality of a batch of wire by submitting it to firing tests under somewhat more exacting conditions (of temperature and time) than would be met in normal processing: the singular feature of the type of embrittlement to which we refer is that it frequently occurs in heaters made from wire which on such firing tests has appeared to be of excellent quality.

The purpose of this communication is to direct attention to what is, we believe, one of the major causes of such embrittlement, namely, surface contamination of the tungsten by nickel. We have found that very slight traces of nickel on the tungsten surface can cause embrittlement. The amount of nickel which is significant is extremely small: a film of the order of 10 A. thick on the surface of otherwise good-quality wire can make that wire so brittle that it cannot be handled, and even smaller amounts can materially impair ductility.

Such traces of nickel are readily picked up on the surface of a heater during the normal processes of manufacture. Making use of electrographic techniques, we have found nickel contamination in damaging quantities to arise from such practices as bending the wire around a nickel former, or winding it over nickel rollers or on to nickel-alloy spools. Spot welding of an uncoated heater to nickel wire can splash embrittling quantities of nickel on to the tungsten in patches as far as two inches from the weld.

On heating contaminated wire there is rapid diffusion of the nickel into the tungsten; when this diffusion occurs the wire is embrittled (brittleness is not apparent at temperatures below about 1,200° C.); but if the contaminated surface of the tungsten can be removed before being heat treated, so that no diffusion of nickel takes place, the wire is undamaged.

Work is proceeding to ascertain whether or not the related elements, iron and cobalt, exhibit similar embrittling properties. Preliminary indications are that both metals do so—iron only slightly, and cobalt to a lesser extent than nickel.

We cannot yet offer a theoretical explanation of these phenomena.

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Large Type II Diamonds

In an article on "The Problem of the Two Types of Diamond" by Prof. G. B. B. M. Sutherland, D. E. Blackwell and W. G. Simeral[1], it is remarked that "in our experience all large diamonds of gem-stone quality are always type I diamonds". Actually, the four largest and finest diamonds we have come across at the Diamond Research Laboratory since 1951 were all of type II. Some details are given in Table 1.

Table 1

Type	Weight in carats	Colour	Origin	Transmittance in ultra-violet	Laminations	Lit. reference
II	34½	Pure white	Premier Mine	Down to 2250 A.	Present	*Research*, **4**, 131 (1951)
II*b*	66	Pure white	Premier Mine	Down to 2750 A., and probably shorter	Present	*Physica*, **18**, 489 (1952)
II*a*	160	Pure white	S.W. Africa	Down to 2375 A.	Present	Laboratory Report No. 94, May 1, 1951. *Gems and Gemmology*, **7**, 275 and 287 (1953)
II*b*	426¼	Pure white	Premier Mine	Down to 2375 A.	Present	*J. Gemmology*, **4**, 300 (1954)

The difference between types II*a* and II*b* is that II*a* is an excellent insulator for electricity whereas II*b* is a temperature-sensitive semiconductor. Type II*b* shows, moreover, a green-blue phosphorescence after having been irradiated with short-wave ultra-violet (resonance line of mercury, about 2536 A.) whereas type II*a* does not. None of the diamonds of Table 1 fluoresces in the near ultra-violet, that is, about 3650 A. At the time when the 34½ carat diamond was examined, the existence of type II*b* diamonds was still unknown.

The diamonds of Table 1 are all of the finest gem quality, and it is my firm opinion that nearly all the larger gem stones belong to this category. However, it is true that not one of the larger gem diamonds shows a regular crystal form. Quite a few of them show not only growth triangles but also growth figures of a hexagonal shape.

Finally, it is worth while mentioning that the Premier Mine produces a very much higher percentage of type II diamonds than any other mine.

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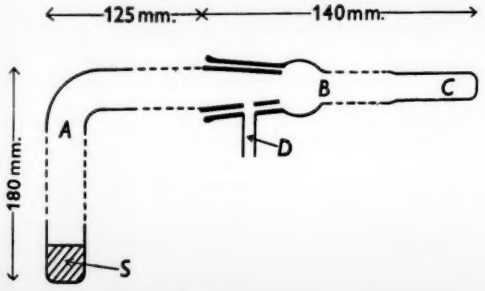
Effect of Ionizing Radiation on Hæmoglobin and Cytochrome c

THE study of the oxygen-effect in ionizing radiation may elucidate the part which indirect effects play in inhibiting biological cell functions through the action of oxidizing radicals and hydrogen atoms, which are formed from water. In continuation of previous work[1] the following substances have been exposed to X-rays: oxyhæmoglobin (HbO_2) in air, hæmoglobin (Hb) in nitrogen, methæmoglobin (Methb) in air and in nitrogen, reduced and oxidized cytochrome *c* in air and in nitrogen. The concentration of hæmoglobin (in phosphate buffer *p*H 6·0) varied between $1·3 \times 10^{-5}$ and $3·2 \times 10^{-4}$ *M* and that of cytochrome *c* (in phosphate buffer *p*H 7·3) between 0·8 and $2·0 \times 10^{-5}$ *M*. The X-ray dose varied between 0·8 and 75·0 kr. (190 kVp., no added filtration, dose-rate 4·8 kr./min.). Changes in absorption spectra of the substances examined, which were measured spectrophotometrically, were a measure of the irradiation effect.

The spectra after irradiation were found to be unstable and to alter with time, especially with samples irradiated in nitrogen. This was due to the fact that the irradiated substances had become easily oxidizable, and was most pronounced with cytochrome *c*. In order, therefore, to prevent changes of the spectra which, although induced by radiation, occurred only subsequent to irradiation, they had either to be fixed in the state obtaining at the end of the irradiation procedure, or oxygen had to be excluded during measurement. The former was done with hæmoglobin by means of carbon monoxide, which combines with the reduced form and prevents further oxidation by molecular oxygen. Reduced cytochrome *c*, on the other hand, which does not combine with carbon monoxide, cannot be so protected. Experiments with cytochrome *c* were therefore carried out in a special tube (Fig. 1), which allows irradiation and spectrophotometric measurement to be carried out without exposing the irradiated sample to air.

The design of the tube, which can be evacuated and filled with nitrogen, is self-explanatory. The sample *S* is irradiated in *A* and then tipped through *B* into the optical cell *C* (which is protected by lead during irradiation). Parts *A* and *B* are separated from each other while nitrogen under pressure is applied through *D*, and *B* is closed with a ground-in glass stopper. An adaptor to the spectrophotometer, which excludes the light, allows the spectrum to be measured in the ordinary way. The results obtained are briefly as follows.



1. Combined irradiation- and spectrophotometry-tube

(1) *Hæmoglobin.* The primary change depends on the initial state of the material, that is, whether it is oxidized or reduced, and is independent of the presence of oxygen. Thus hæmoglobin becomes oxidized and methæmoglobin becomes reduced. The oxidation of oxyhæmoglobin in air and of hæmoglobin in nitrogen is of about the same order, while reduction of methæmoglobin is greater in nitrogen than in air. The rate of oxidation or reduction increases with increasing X-ray dose; conversely, at a given dose, it increases with decreasing concentration of hæmoglobin. Oxidation or reduction, however, is in neither case directly proportional to the X-ray dose, because of the occurrence of secondary reactions. Thus, for example, methæmoglobin, which becomes reduced during irradiation in nitrogen (presumably by hydrogen atoms), is re-oxidized (presumably by hydroxyl radicals). Moreover, it is not re-oxidized to methæmoglobin but to a green pigment showing a strong band at 615 mμ. The rate of this secondary oxidation is greater in nitrogen than in air, and in both cases it is the greater the lower the concentration of hæmoglobin.

(2) *Cytochrome c.* Like hæmoglobin, ferrocytochrome becomes oxidized both on irradiation in air and in nitrogen—the rate of oxidation being greater in air—and ferricytochrome becomes reduced on irradiation in nitrogen. Unlike hæmoglobin, on the other hand, ferricytochrome does not appear to be affected by irradiation in air at doses up to 35 kr. (denaturation of the protein at high X-ray doses is outside the scope of this work). There is, furthermore, no formation of a green pigment from either ferri- or ferro-cytochrome during or after irradiation in air, nor during irradiation in nitrogen. However, cytochrome irradiated in nitrogen turns rapidly green on admission of oxygen after irradiation. This occurs irrespective of whether the sample had been partially oxidized or reduced during irradiation, and is accompanied by the disappearance of the band of ferrocytochrome at 550 mμ and the appearance of a new band at about 600 mμ. Failure to observe anaerobically irradiated cytochrome without exposing it to molecular oxygen had previously led to the statement[2] that no difference exists between aerobically and anaerobically irradiated ferrocytochrome. This was coupled with theoretical considerations concerning the oxygen effect, which are now no longer tenable.

The catalytic activity of irradiated cytochrome *c* was finally tested by determining the rate at which it catalyses the oxidation of sodium succinate in an enzymic system (horse kidney preparation) which is otherwise practically devoid of cytochrome *c*[3]. After a dose of 36 kr. in air, the rate of succinic oxidation was decreased by only 15 per cent, which is accounted for by destruction of the cytochrome (as calculated from the absorption at 550 mμ after addition of sodium hyposulphite). When applying the same dose in nitrogen, the loss of catalytic activity was slightly larger, namely, 35 per cent. It is believed that this additional loss of activity is due to the fraction of cytochrome which had been irreversibly oxidized to a green pigment on admission of oxygen after the irradiation.

The experiments thus show that, while the initial reaction brought about by ionizing radiation is mainly dependent on the state of the material and its ability to react with either oxidizing or reducing agents independently of the presence of oxygen, the initial reaction product may undergo secondary, or even a series of further, changes during irradiation

or, as with cytochrome *c*, after irradiation on admission of oxygen to an anaerobically irradiated sample.

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Paper Electrophoresis of Polyhydric Alcohols

The polyhydric alcohols or polyols are a group of carbohydrates important both biologically and industrially. Apart from laborious column techniques[1], there is no satisfactory micro-method available for the resolution of mixtures of hexitols (sugar alcohols) by themselves or, in particular, in the presence of hexoses.

Several workers[2] have reported on the application of paper chromatography to this problem but have stated that they found the separation of sorbitol, mannitol and dulcitol from one another and from glucose impossible, since their R_F values in a great number of different solvent systems were practically identical. Casimir and Huygens[3] reported recently that they succeeded in separating sorbitol from some simple sugars by running multiple two-dimensional chromatograms or one-dimensional chromatograms for 150 hours with butanol–benzene–pyridine–water (5 : 1 : 3 : 3)[4] as the solvent system. With a different solvent the separation of sorbitol from mannitol was possible in the same time, but neither sorbitol nor mannitol could be separated from dulcitol.

Michl[5] described the separation by paper electrophoresis of three polyols of widely differing mobilities, namely, ethylene glycol, glycerol and mannitol.

The application of the author's high-voltage technique[6] to the resolution of mixtures of polyols and sugars as sugar-borate complexes proved it to be a powerful tool, even in cases of small differences in mobilities, for example, mannitol and glucose, or sorbitol and fructose. Fig. 1 illustrates some of the results obtained.

A shows the clean separation of the three hexitols from one another and the tetritol (erythritol) in three hours at 2,000 V. in 0·05 *M* borate buffer of *p*H 9·2; *B* shows the result obtained by doubling the voltage and reducing the time to one-half. Agreement is quite good with regard to the directly proportional relationship between migration-rates and applied potential gradients. The slight displacement of the two erythritol spots is an effect occasionally noticed, the course of which is suspected to be uneven pressure exerted on the paper strip by the cooling plates, and is at present under investigation. The application of such high potential gradients as 80 V./cm. and current values of up to 10 m.amp./cm. proved to be feasible, although entailing an energy dissipation of up to 200 watts. The temperature of the cooling water (tap water) is significant in this case. The separation of the hexitols from the hexoses glucose, fructose, mannose and sorbose is shown in Fig. 1, *C* and *D*.

Inositol, a cyclitol, although having a slightly lower mobility than glycerol, is not easily separated from it (Fig. 1, *E*). Two important trioses, dihydroxyacetone and glyceraldehyde, though not belonging to the group of polyols, but the detectability of which in mixtures of metabolic products is highly desirable, cannot be separated because their mobilities appear to be similar. These compounds, however, can be separated by paper chromatography using the solvent system *n*-propanol : water : ethyl acetate (7 : 2 : 1)[7] in less than thirty hours, while the separation of adonitol from sorbitol (Fig. 1, *F*) can be achieved in forty hours. The difference between the slightly lower mobility of adonitol, a pentitol, and that of the nearest hexitol, sorbitol, is not sufficient to enable an electrophoretic separation to be effected. Of further interest in Fig. 1, *F* is the great difference in migration-rates between penta-erythritol, carrying no charge, and erythritol. The spreading of the penta-erythritol spot is obviously due to the nature of the compound. Lead tetra-acetate in benzene, according to Buchanan

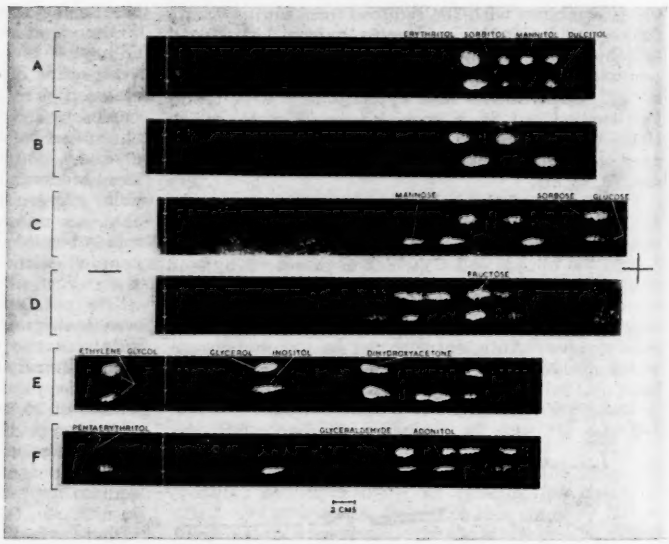

Fig. 1. Electrophoresis of polyhydric alcohols. From left to right: *A*, meso-erythritol, D-sorbitol, D-mannitol, dulcitol; conditions: 40 V./cm., 3·3 m.amp./cm., Whatman No. 3 *MM* 2¼ × 22½ in. strip, 0·05 *M* sodium borate solution, *p*H 9·2, 10 μgm. of each compound, except for 20 μgm. of erythritol, applied 4 in. from cathode end, 3 hr.; *B*, erythritol; sorbitol, mannitol; conditions: 80 V./cm., 6·5 m.amp./cm., 20 μgm. of each compound, 1·5 hr., otherwise the same; *C*, mannose, erythritol, sorbitol, mannitol, glucose, sorbose; conditions: 80 V./cm., 8·5 m.amp./cm. 30 μgm. of mannose, 40 μgm. of sorbose and glucose, 1·5 hr.; *D*, mannose, erythritol, sorbitol, mannitol, fructose, sorbose, glucose; 40 V./cm., 3·4 m.amp./cm. 10 μgm. of fructose, 2·5 hr.; *E*, ethylene glycol, glycerol, meso-inositol, dihydroxyacetone, erythritol, sorbitol, mannitol, dulcitol; 80 V./cm., 7·7 m.amp./cm. 50 μgm. of ethylene glycol, 20 μgm. of glycerol, 1 hr.; *F*, penta-erythritol, ethylene glycol, glycerol, erythritol, DL-glyceraldehyde, adonitol, sorbitol, dulcitol; 80 V./cm., 10 m.amp./cm., 80 μgm. of penta-erythritol, 1·25 hr.; spraying reagent: 1 per cent solution of lead tetra-acetate in benzene, giving white spots on brown background

et al.[1], was found to be the most suitable spraying reagent, and was used throughout, as it did not appear to be inhibited by the presence of borate ions, in contrast to silver nitrate. Good results have also been obtained with the separations of the glycols and their derivatives.

Thanks are due to Mr. H. C. S. de Whalley, director of research, for encouragement, and the directors of Tate and Lyle, Ltd., for permission to publish this communication.

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The Huxley–Wilberforce Debate: a Postscript

The famous occasion when T. H. Huxley crossed swords with Samuel Wilberforce, at the 1860 Oxford meeting of the British Association, has been often described; and recently D. J. Foskett has published[1] Huxley's contemporary account of the encounter. There has recently come to light the draft (in a box file in the basement of the Zoology Department of the Imperial College of Science and Technology) of a note sent by Huxley to Wilberforce early in 1861, as follows:

The Atheraeum.
Jany 3rd, 1861.

Professor Huxley presents his compliments to the Lord Bishop of Oxford—Believing that his Lordship has as great an interest in the ascertainment of the truth as himself, Professor Huxley ventures to draw the attention of the Bishop to a paper in the accompanying number of the *Natural History Review* "On the Zoological Relations of Man with the Lower Animals".

The Bishop of Oxford will find therein full justification for the diametrical contradiction with which he heard Prof. Huxley meet certain anatomical statements put forth at the first meeting of Section D, during the late session of the British Association at Oxford.

Unfortunately, we do not have Wilberforce's reply—if any were sent—to this polite but delicately barbed note.

The *Natural History Review* had been taken over by Huxley and some friends for publication in England, having earlier been published in Ireland under the editorship of Edward Perceval Wright, and it was the first number under the new management which was sent to Wilberforce. "The tone of the Review", Huxley had told Hooker[2], "will be mildly episcopophagous"—a prospect which apparently outweighed the urgings of Darwin[3], Hooker[4] and Lyell[5] that Huxley should not take upon his already heavily burdened shoulders this new editorial duty. Before long, the substance of Huxley's paper was being given in more popular form, as six lectures to working men at the School of Mines in Jermyn Street, under the title "On the Relations of Man to the rest of the Anl. Kingdom"[6]; and after a few lectures Huxley was writing to his wife[7], "My working men stick by me wonderfully, the house being fuller than ever last night. By next Friday evening they will all be convinced that they are monkeys".

The publication of these working-men's lectures in the *Natural History Review* led to an invitation to cover the same ground before the Edinburgh Philosophical Institute. "Fancy unco guid Edinburgh requiring illumination on the subject!" Huxley wrote[8] to his wife. "They know my views, so if they do not like what I shall have to tell them, it is their own fault". Darwin's diplomatic ambiguity, "Light will be thrown on the origin and the history of man", was not for Huxley; as he put it to Hooker[9], "I told them in so many words that I entertain no doubt of the origin of man from the same stock as the apes". On reading an account of the lectures, Darwin wrote[10] jubilantly, "By Jove you have attacked Bigotry in its strong-hold. I thought you would have been mobbed"; and Lyell[11] urged Huxley to tone down some of the passages when he came to publish his little book, "Evidences as to Man's Place in Nature". Huxley accepted some of Lyell's suggestions, but[12] he found it "a great piece of self-denial . . . and I hope I shall be rewarded for the virtue". As he saw more of the proofs, Lyell became really alarmed and wrote[13], "if the worst is in sheets not yet thrown off do let me see it that I may try & suggest something of the suaviter in modo—", adding as a monitory postscript, "I hope you send none of these *dangerous* sheets to press without Mrs. Huxley's imprimatur". However, the book went to press and was a great success. As Huxley wrote to Lord Rosebery some thirty years later[14], "abuse for six or seven years . . . is not of the greatest consequence, when one happens to be in the right & stands to one's guns. But you really cannot imagine what a disreputable person the author of M.P. in N. was in the decade 1860–70—and now the doctrines of that horrid book are taught in the schools".

Grateful acknowledgment is made to the Governing Body of the Imperial College of Science and Technology for permission to quote from the Huxley Papers in its possession.

Cyril Bibby

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Barnet, Herts.

[1] *Nature*, **172**, 920 (1953).
[2] "Huxley Papers", **2**, 67 (July 17, 1860).
[3] "Huxley Papers", **5**, 125 (July 20, 1860).
[4] "Huxley Papers", **3**, 119 (July 18, 1860).
[5] Lyell, Mrs., "The Life, Letters and Journals of Sir Charles Lyell", **2**, 366 (Murray, London, 1881).
[6] "Huxley Papers", Diary, February 21. 1861.
[7] Huxley, Leonard, "The Life and Letters of Thomas Henry Huxley", **1**, 190; March 22, 1861 (Macmillan, London).
[8] Huxley, Leonard, "The Life and Letters of Thomas Henry Huxley" **1**, 192; April 10, 1861 (Macmillan, London).
[9] "Huxley Papers", **2**, 112 (January 16, 1862).
[10] "Huxley Papers", **5**, 167 (January 14, 1862).
[11] "Huxley Papers", **6**, 66 (August 9, 1862).
[12] "Huxley Papers", **30**, 41 (August 17, 1862).
[13] "Huxley Papers", **6**, 70 (October 1862).
[14] "Huxley Papers" **24**, 213 (June 2, 1894).

FORTHCOMING EVENT

Saturday, August 27—Friday, September 2

Institute of Medical Laboratory Technology (at the University, Nottingham)—Seventh Triennial Conference.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Advisory Officer (with an honours degree in agriculture or pure science, and a special interest in grassland work) in Agricultural Botany—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (August 27).

Assistant, Grade B (with a good honours degree in chemistry, and preferably with teaching experience) to teach chemistry of the standard of intermediate science—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (August 27).

Assistant, Grade B (graduate in electrical engineering or with equivalent professional qualifications and appropriate industrial experience, and preferably with experience in the U.H.F. field) in Electrical Engineering—The Registrar, Hatfield Technical College, Roe Green, Hatfield (August 27).

Research Assistant in Pharmacology—The Registrar and Secretary, The University, Bristol (August 27).

Senior Research Student in either Engineering or Metallurgy—The Registrar, University College, Singleton Park, Swansea (August 27).

Senior Research Officer (with a degree in mathematics or one of the natural sciences, and preferably with experience of planning and conducting surveys) to work as one of a team establishing data on which design may be based, with particular responsibilities in the field of studying functional requirements of laboratory and agricultural buildings—The Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1 (August 31).

Assistant Experimental Officer (with a degree in botany or an allied biological science) in the Department of Plant Breeding, to assist with cytological studies of horticultural crops—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (September 3).

Soil Conservation Officers (graduates in agriculture or agricultural engineering) in the Federal Department of Conservation and Extension, Federation of Rhodesia and Nyasaland—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (September 6).

Lecturer in the Department of Electrical Power Engineering and a Lecturer in the Department of Electronic Engineering—The Registrar, The University, Liverpool (September 10).

Assistant Plant Nutrition Chemist (with a degree in science or chemistry, preferably with honours)—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 12).

Lecturer in Biology at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Adelaide, September 15).

Lecturer (preferably with special qualifications in organic chemistry) in Chemistry—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (September 15).

Scientific Assistant (M.R.C.V.S. or its equivalent; or a degree in science or in arts, and a knowledge of languages)—The Director, Commonwealth Bureau of Animal Health, Veterinary Laboratory, Weybridge, Surrey (September 15).

Reader in Applied Mathematics at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 21).

Lecturer in Physical Geography at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 24).

Senior Lecturer in Civil Engineering (Hydraulics), and Senior Lecturer in Civil Engineering at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Lecturer in Economic Statistics—The Secretary of Faculties, University Registry, Oxford (October 1).

Assistant, Grade B (with graduate or A.R.I.C. qualifications) in Chemistry—The Principal, Technical College, Queen Street South, Huddersfield.

Assistant Statistician (with a degree in mathematics with statistics or equivalent qualifications, and preferably with an interest in the use of punched-card machines and electronic computing equipment) in the Department of Statistics, to carry out the more advanced type of statistical computations and to supervise the routine statistical work of the computing staff of the Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Computer (preferably woman graduate) in the Mathematics Department—The Assistant Secretary, University College, Gower Street, London, W.C.1.

Head of the Department of Chemistry (including Colour Chemistry and Dyeing)—The Principal, Technical College, Queen Street South, Huddersfield.

Laboratory Assistant in the Physics Department—The Bursar, Epsom College, Surrey.

Metallurgist (with a first- or second-class honours degree or equivalent qualification in metallurgy, and several years research experience on non-ferrous metals, preferably including copper and aluminium alloys) at the Ministry of Supply Armament Research and Development Establishment, near Sevenoaks, Kent, for research and development in the field of non-ferrous metallurgy—The Ministry of Labour and National Service, Technica and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.605/5A.

Physicist, Basic grade (honours graduate in physics and interested in a career in medical physics, and preferably with a specialized knowledge in one of the following fields: electronics, physical chemistry, radiology)—The Medical Superintendent, Dundee Royal Infirmary, Dundee.

Physicist (with experience of electronic techniques) in the Davy Faraday Research Laboratory of the Royal Institution, to carry out research on methods of dating archæological material by means of radio-carbon measurements—Sir Lawrence Bragg, F.R.S., The Royal Institution, 21 Albemarle Street, London, W.1.

Physicists (Scientific Officer and Experimental Officer class) in the Reactor Physics Division, to study the physical principles underlying a wide variety of nuclear reactors—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/38.

Physicists (with an honours degree in physics, Associates of the Institute of Physics, or equivalent qualifications) at Windscale Works, Cumberland (Ref. 1,063), and Dounreay Works, Caithness, Scotland (Ref. 1,064), to be responsible to Group Managers for the efficient operation of the Health Physics and Safety Groups—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, quoting appropriate Ref. No.

Research Assistant (graduate in chemistry and preferably an interest in, or experience in, physical and colloid chemical techniques) in the Department of Chemistry and Food Technology, for work on fats or allied substances (phospholipids)—The Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

Senior Experimental Officer (with at least H.S.C. in science subjects or equivalent qualifications, and experience in inorganic and radiochemical analysis) in the Chemical Engineering Division to supervise and train staff engaged on analytical problems associated with pilot plant operation—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/301.

Theoretical Physicist (Principle or Senior Scientific Officer grade) (with a first- or second-class honours degree in physics and at least three years postgraduate research experience, preferably in the field of motion and coagulation of particulate suspensions), to work on problems of size distribution in coagulating and dispersing particulate suspensions—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 726/34.

Zoologist (Senior Scientific Officer or Scientific Officer grade) (university graduate with first- or second-class honours), for general and experimental work on marine plankton—The Director, Marine Station, Millport, Isle of Cumbrae, Scotland.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

National Museum of Wales. The Museum Schools Service: the First Five Years. Pp. 12. (Cardiff: National Museum of Wales, 1955.) 6*d*. [136

Aero Research Technical Notes. Bulletin No. 148: Aero Research Limited, 1934–1955. Pp. 10. (Duxford: Aero Research Limited, 1955.) [136

Forestry Commission. Agreements on Afforestation in the Lake District: Reports by the Joint Informal Committee of the Forestry Commission and the Council for the Preservation of Rural England. Pp. 10. 6*d*. net. Leaflet No. 33: Collection and Storage of Ash, Sycamore and Maple Seed. Pp. 10. 6*d*. net. (London: H.M. Stationery Office, 1955.) [206

Building Research Station Digest No. 77: Linoleum. Pp. 6. (London: H.M. Stationery Office, 1955.) 3*d*. net. [206

Department of Scientific and Industrial Research. Report of the Food Investigation Board, with the Report of the Director of Food Investigation for the year 1954. Pp. iv+72. (London: H.M. Stationery Office, 1955.) 3*s*. net. [206

East Africa Royal Commission 1953–1955 Report. Pp. xiv+482+4 maps. (London: H.M. Stationery Office, 1955.) 17*s*. 6*d*. net. [206

Other Countries

Virology. Vol. 1, No. 1 (May 1955). Edited by George K. Hirst, D. M. Black and S. E. Luria. Pp. 140. (New York: Academic Press Inc., 1955.) Volume 1–9 dollars. [136

Cawthron Institute. Cawthron Lecture Series No. 27: Geothermal Energy. By Dr. W. M. Hamilton. Pp. 28+2 plates. (Nelson: Cawthron Institute, 1955.) [136

Mauritius Sugar Industry Research Institute. Annual Report, 1954. Pp. i+86. (Réduit, Mauritius: Mauritius Sugar Industry Research Institute, 1955.) [136

Kungl. Skogshögskolans Skrifter. Nr. 20: Vattnet i Skogsmarken. Studier med hansyn särskilt till ytvattnets, sjunkvattnets och grundvattnets uppkomst och sammansättning. Av Tryggve Troedsson. Pp. 215. (Stockholm: Skogsbiblioteket Skogshögskolan, 1955.) 10 kronor. [136

Papers in Physical Oceanography and Meteorology published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. Vol. 13, No. 1: The Electrical Field Induced by Ocean Currents and Waves, with Applications to the Method of Towed Electrodes. By M. S. Longuet-Higgins, M. E. Stern and Henry Stommel. (Contribution No. 690 from the Woods Hole Oceanographic Institution.) Pp. 37. (Woods Hole, Mass.: Woods Hole Oceanographic Institution, 1954.) 1.25 dollars.

West African Institute for Oil Palm Research. Quarterly Progress Report No. 12: January 1st 1955 to March 31st 1955. Pp. 23. (Benin City: West African Institute for Oil Palm Research, 1955.) [136